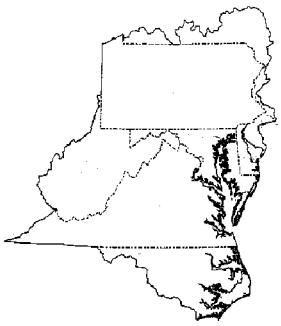

INTEGRATING ENVIRONMENTAL MONITORING AND RESEARCH IN THE MID-ATLANTIC REGION

Proceedings of a Workshop

College Park, Maryland

April 10-12, 1996

Committee on Environment and Natural Resources

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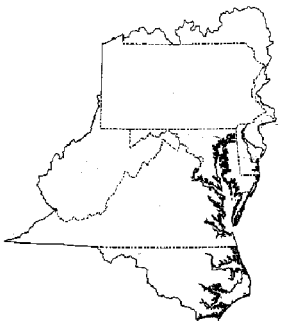

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Contents

Executive Summary

The Committee on Environment and Natural Resources (CENR) of the National Science and Technology Council is developing a National Environmental Monitoring and Research Framework. At the invitation of the President's Office of Science and Technology Policy (OSTP) approximately 110 individuals, including representatives of state environment and natural resource agencies and regional commissions, university scientists, representatives of non-governmental organizations and corporations, and federal agency program managers, met on April 10-12, 1996 to determine whether and how best to implement a Regional Pilot in the Mid-Atlantic area under this Framework. Workshop participants were charged to identify: (1) the key resource management issues in the region around which to integrate environmental monitoring and research; (2) monitoring and supporting research needed to provide information relevant to resolving these issues; and (3) next steps for implementing an integrated regional framework by using, modifying, and building on existing federal and non-federal programs.

For the purposes of the Regional Pilot, the Mid-Atlantic region includes the states of Pennsylvania, West Virginia, Maryland, Delaware, and Virginia (Federal Region III), the Delaware Bay, Chesapeake Bay and Albemarle-Pamlico Sound complex and their watersheds (which adds portions of New York, New Jersey and North Carolina), and the coastal ocean extending to the edge of the continental shelf. It is also recognized that the direct influence of atmospheric sources and processes in this region extends to an even larger "airshed" which requires monitoring.

In general, participants representing organizations within the region strongly support the goal of integrated environmental monitoring and research as articulated in the CENR National Framework. Participants believe that significant value would be added by better integration of monitoring programs and of monitoring and research within the region. This is particularly so because many of the environmental problems faced in the Mid-Atlantic region involve interactions of atmospheric changes, land use and cover, and aquatic and coastal habitats and resources.

Participants found that the National Framework can be improved by more attention to linkages with the users of monitoring information, including: responsiveness to decisionmakers' information needs; interpretation of results; integration of environmental and resource data with social and economic considerations in assessments; dissemination of information to decisionmakers and the public; and anticipatory prediction. In addition, in order to effect integration of monitoring programs, there is a need for driving hypotheses and models; more inclusion of monitoring of conditions that directly affect human health and well-being; development of methods that link space-based and site-based measurements; and more aggressive inclusion of non-federal participants than is reflected in the working draft Framework. Finally, the integration between research and monitoring must progress and address such difficult issues as quality control of research and monitoring performed within all sectors, detectability of change, and the development of human resources needed for effectively integrated monitoring and assessment over the long term.

Reference Issues were identified as representative of the kinds of environmental and natural resource issues which are at present and for the foreseeable future, subject to protection, management and restoration activities in the region. In the view of the regional participants, if the implementation of the Mid-Atlantic Regional Framework does not produce information which can improve the effectiveness of protection and management activities which address these issues, it will not be perceived as relevant, not produce incentives for adaptation of existing monitoring programs, and ultimately not be embraced and sustained. The Reference Issues identified are Changes in Land Use and Cover, Nutrient Over-enrichment, Water Resources for Human Use, Atmospheric Condition and Deposition, Stream and Wetland Habitat Protection and Restoration, Coastal Fisheries Resources, and Environmental Quality and Human Health in Urban Areas.

Workshop participants identified important contributing elements for the Regional Pilot and key gaps in breakout sessions organized by environmental media: the atmosphere and terrestrial, aquatic and coastal environments. They then considered steps toward implementing the Regional Pilot with respect to information and data management, integration of existing monitoring programs, integration of research and monitoring, assessment, and organizational requirements. Implementation of the Mid-Atlantic Pilot will require high-level and long-term commitment and participation among federal and state agencies through an Executive Committee and steadfast attention to execution by a Program Coordination/Implementation Committee. In addition, an Executive Secretary and support office will be required. However, to be successful the Mid-Atlantic Pilot must take advantage of ongoing management and assessment activities which include monitoring or heavily use monitoring results, such as the Mid-Atlantic Integrated Assessment, the Chesapeake Bay Program, the Ozone Transport Commission, National Estuary Program, and the Mid-Atlantic Highlands Coordinating Council.

In discussion of the implementation of the Mid-Atlantic Pilot among all participants at the conclusion of the Workshop, the central importance of additional assessment was stressed, both in the sense of more in-depth appraisal of what needs to be known to support wise environmental management and in the sense of determining our ability to truly integrate existing regional programs. It was the widely held view of Workshop participants that assessment, i.e. the marshalling of scientific evidence to determine the nature and relationship of environmental problems and predict outcomes of actions, be given primacy in the implementation of integrated monitoring within the region. One of the key Workshop recommendations is that a core assessment be initiated immediately, prior to major structural reorganizations or commitments which are difficult to reverse. This assessment should include an inventory of environmental data and information currently available and provide direction for the Regional Pilot and the National Frameworks on a regular basis in support of their incremental implementation and result in a comprehensive assessment in approximately two years. That assessment will provide long-term guidance for sustained integrated monitoring.

A key need in these assessments and for underpinning the integration of various programs is in the area of scaling. It was the consensus of the Workshop that the Regional Pilot should address the entire region, but it is clear that some sub-regions are being and will be monitored much more intensively and at different time scales. Thus, our ability to extrapolate and

interpolate information across space and time scales will be critical to the success of regional monitoring—as it will be for national monitoring.

Finally, it was pointed out that there are regional issues and existing assessment programs which should serve as a strong foundation for regional monitoring in the Mid-Atlantic, such as the Mid-Atlantic Highlands Assessment and the Chesapeake Bay Program. These programs address the issues of air quality, atmospheric sources, land use and cover, and water quality in an integrated way and thereby provide an "inherent comparative advantage" for the region.

1. Introduction

Monitoring of the environment is conducted for various resources—soil, water, air, plants and animals—for a wide variety of purposes, on a broad range of scales, and by an extensive array of organizations. The combined experience of scientists and resource managers has made it clear that ecosystems are not simply composed of independent resources but that these resources interact on a range of spatial and temporal scales. Yet, current environmental monitoring programs, while often effective in tracking specific components of ecosystems are found by resource managers to be inadequate and inefficient in providing critical information on how these different components interact (NSTC, 1996). This has led to efforts to establish and implement a national environmental monitoring strategy which, to this point, have been unsuccessful in providing the needed comprehensiveness and integration. Ambitious national environmental programs such as the Environmental Monitoring and Assessment Program (EMAP) have failed to integrate monitoring across resources and take advantage of other existing national and regional monitoring activities. On the other hand, efforts to coordinate existing programs have not yet succeeded in achieving intercomparability, functionally integrating resources, or filling critical gaps.

Shortly after its formation in 1993, the National Science and Technology Council (NSTC) convened national experts outside of government to recommend priorities for federal environmental science programs (NSTC, 1995a). That led to follow-up activities by the Council's Committee on Environment and Natural Resources (CENR), including one to determine how to reach the national goal for ecosystem science (NSTC, 1995b) to understand, predict and manage our ecological systems for sustained use and enjoyment. It specifically recommended: "a focused research and monitoring program that improves the information base needed to conduct regional, national, and international syntheses." To act on this recommendation, CENR convened a team of federal scientists and program managers, the Environmental Monitoring Team, "to develop a national framework for integration and coordination of environmental monitoring and related research through collaboration and building upon existing networks and programs." The Environmental Monitoring Team produced a proposed Framework for integrating the Nation's major environmental monitoring and research networks and programs "to allow understanding, assessment, evaluation, and forecasting of the Nation's renewable natural resources at national and regional scales" (NSTC, 1996).

The guiding principles for the Framework require it to be driven by policy needs (effectively addressing environmental issues of present and future concern), scientific understanding (based on sound scientific and statistical methods), and interagency cooperation (involving appropriate federal, state, tribal, private and international organizations). In addition it should be built using successful "keystone" monitoring and research programs and must be cost-effective, continuous, interoperable, adaptive and accessible (NSTC, 1996). The CENR Framework envisions a hierarchical structure for integrating monitoring that: (1) characterizes specific properties of large regions by continuous measurement (e.g. remote sensing); (2) characterizes specific properties of large regions by sampling; and (3) focuses on the properties and processes of specific locations.

As a critical step toward implementing the Framework as a National Integrated Environmental Monitoring Program the CENR Environmental Monitoring Team recommended convening a workshop to develop an implementation plan for the Framework in a pilot region. It reasoned that implementation first on a regional scale rather than nationally has the advantage of requiring smaller modifications of agency budgets and programmatic objectives while allowing a field test of the proposed Framework. The Mid-Atlantic region was selected as the first pilot region because regional-scale environmental assessments are already ongoing and multi-jurisdictional environmental management programs in this region (e.g. the Chesapeake Bay Program) rely on environmental monitoring programs which could benefit from better integration.

From a Mid-Atlantic perspective, the type of integrated monitoring conceptualized by the CENR Framework is particularly timely. Not only are policymakers and managers struggling to better manage environmental issues which involve multiple media (air, soil, water, and biota) and affect several resources (e.g., agriculture, forests, and fisheries), but scientists are beginning to make advances in understanding phenomena operable on different space and time scales. As we progress toward the goals of ecosystem management (Interagency Ecosystem Management Task Force, 1995) and sustainable development (President's Council on Sustainable Development, 1996), innovative and responsive environmental monitoring must be a key element.

The Mid-Atlantic Regional Pilot Workshop was held on April 1-12, 1996, at College Park, Maryland. This report summarizes the deliberations and recommendations of that workshop. It is intended that this report provide guidance for the implementation of a Mid-Atlantic Integrated Environmental Monitoring Program and useful input to a subsequent workshop to develop a national implementation plan for the Framework.

2. Workshop Scope and Strategy

The objectives of the Workshop were to: (1) obtain the views of regional environmental managers and scientists regarding the Framework and its utility in the Mid-Atlantic region; (2) identify important regional environmental issues to which integrated monitoring should be responsive (reference issues); (3) identify ongoing monitoring and research programs which could contribute and important gaps which presently exist; and (4) recommend implementation strategies and activities.

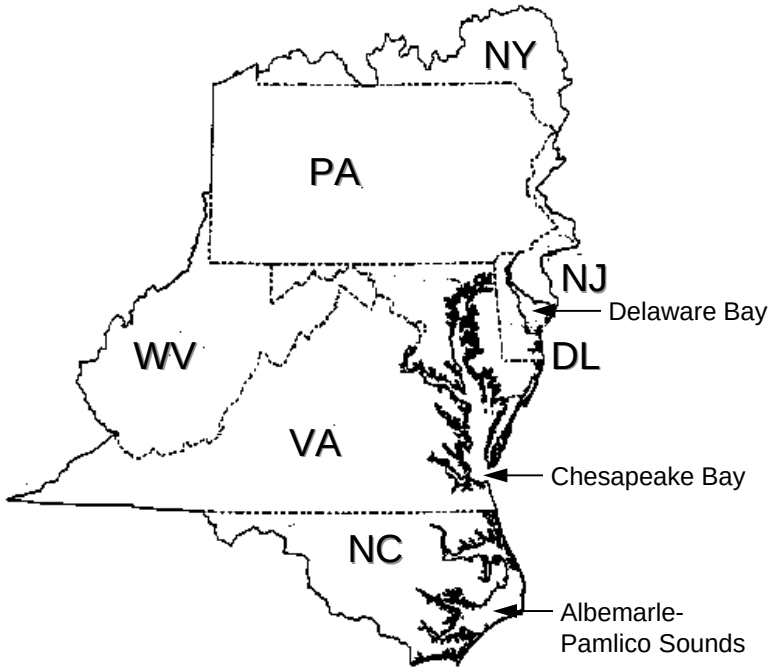

Figure 1. The Mid-Atlantic Region as defined for the purposes of the Regional Pilot Integrated Monitoring Program.

For the purpose of the Regional Pilot, the Mid-Atlantic Region is operationally defined as Federal Region III (including the states of Pennsylvania, Delaware, Maryland, Virginia and West Virginia) plus those regions of the catchment basins of the Delaware Bay, Chesapeake Bay, and Albemarle and Pamlico Sounds which fall in neighboring states (portions of the states of New Jersey, New York, and North Carolina, Figure 1). Thus, the region is defined by a combination of physiographic (the three large estuaries and their watersheds) and geopolitical criteria. Its land area is identical to that considered by the Environmental Monitoring and Assessment Program Landscapes component (Kepner, et al., 1995), but the region also includes the estuarine

environments and coastal ocean (including the continental shelf).

Participants in the Workshop included approximately 110 individuals representing a wide variety of federal agencies (Departments of Agriculture, Commerce, Energy and Interior, Environmental Protection Agency, National Aeronautics and Space Administration, National Science Foundation, and Central Intelligence Agency), agencies of the states of Delaware, Maryland, New York, North Carolina, Pennsylvania, South Carolina, West Virginia, and Virginia, multi-state commissions, universities within and outside of the region, non-governmental organizations and corporations. A listing of these participants is given in Appendix 1.

During the opening session of the Workshop, presentations by Dr. Rosina Biernbaum of the President's Office of Science and Technology Policy, Dr. Robert Huggett, EPA Assistant Administrator for Research and Development, and Dr. Michael Ruggiero of the National Biological Service and Co-Leader of the CENR Environmental Monitoring Team, provided background on the development of the Framework and the context for recommendations on its implementation. Messrs. J. Randy Pomponio and Thomas DeMoss of EPA Region III reviewed the objectives of the Mid-Atlantic Integrated Assessment (MAIA) and its results to date. The remainder of the workshop consisted of three breakout sessions, each followed by a plenary meeting to report and discuss the recommendations of each breakout group. These plenary discussions were moderated by the Workshop Chair, Dr. Donald Boesch of the University of Maryland Center for Environmental and Estuarine Studies, who was also responsible for editing the Proceedings.

The breakout sessions were part of the three-step strategy to meet the Workshop objectives:

- **Utility of the Framework and Reference Issues** . During the first session, five groups of participants (randomly assigned) each considered the utility of the Integrated Monitoring Framework applied to the Mid-Atlantic region and identified potential reference issues.
- **Opportunities and Needs**. During the second breakout session, four groups of participants identified ongoing monitoring and research programs which could contribute within separate environmental media (atmospheric, terrestrial, aquatic, and coastal), opportunities for better integration, and significant gaps. A fifth group addressed opportunities and needs for regional synthesis across environmental media.
- **Functional Implementation of Mid-Atlantic Re gional Pilot**. During the final breakout session, groups identified implementation strategies and actions to better integrate monitoring and research efforts into a useful regional framework, with separate groups addressing information and data management; integration of research and monitoring; integration of monitoring programs; assessment and transfer of information; and Regional Pilot implementation.

The participants in the various breakout groups are identified in Appendix 1. The breakout group chairs and rapporteurs are listed in Appendix 2. In addition to the reports of the

rapporteurs, useful input to this Workshop Report was provided in a detailed proceedings of the Workshop that was prepared by EMS, Inc.

3. Utility of the CENR Framework in the Mid-Atlantic Region

In general, Workshop participants, representing both the scientific community and organizations that conduct and use the results of monitoring within the region, strongly support the goal of integrated environmental monitoring and research articulated in the Framework proposed by the Committee on Environment and Natural Resources (NSTC, 1996). Participants believe that significant value would be added by better integration of monitoring programs and of monitoring and research within the region. This is particularly so because many of the environmental problems faced in the Mid-Atlantic region involve interactions of atmospheric changes, land use and cover, and aquatic and coastal habitats and resources. The nexus of air quality, spreading urban development, habitat destruction, and degraded water quality requires that environmental monitoring and assessment be much better integrated than it presently is if the various responsible federal and state agencies are to meet their responsibilities.

Participants found that the Framework can be improved by more specific attention to **linkages with the users of monitoring information** , including:

responsiveness to decisionmakers' information needs;

interpretation of results;

more specific attention to data management and access;

integration of environmental and resource data with social and economic considerations in assessments;

dissemination of information to decisionmakers and the public; and

anticipatory prediction.

In addition, in order to effect **integration of monitoring programs** , there is a need for more than is reflected in the working draft Framework in terms of:

driving hypotheses and models;

more inclusion of monitoring of conditions that directly affect human health and well-being;

development of methods that link space-based and site-based measurements;

inclusion of Index Sites that are intensely used, manipulated, or managed (in order to assess management practices, remediation, and restoration), in addition to relatively natural sites; and

more aggressive inclusion of non-federal participants, particularly as this may help incorporate more spatially focused, non-federal monitoring programs within the Framework..

Finally, the **integration between research and monitoring** must progress beyond "lip

service" and address such difficult issues as:

quality control of research and monitoring performed within all sectors;

detectability of change; and

the development of human resources needed for effectively integrated monitoring and assessment over the long term.

4. Reference Issues for Mid-Atlantic Region

The first breakout groups were asked to identify five important environmental or natural resource issues which are particularly important in the Mid-Atlantic region. The concurrent groups used different levels of specificity. Furthermore, constraining the number of issues to five often produced lists of highly generalized topics. The plenary discussion was spirited, but eventually led to general consensus on the particular importance of the following seven issues in the Mid-Atlantic region. These are not the only important issues for the region, nor do they necessarily represent the most direct concerns of the public. Also, obviously they do not include issues which are, at the moment, unknown or underappreciated but may emerge as important in the future. Rather, they have been selected to as "reference issues" to represent the kinds of environmental and natural resource issues which are at present, and for the foreseeable future, subject to protection, management and restoration activities in the region.

It is also acknowledged that the issues could be described in different ways, e.g. from a resource or process perspective. Also, it is clear that many of these issues are clearly interrelated and that integrated regional monitoring ultimately must reflect these interrelationships.

The purpose of identifying Reference Issues in the Workshop is to provide a test of relevance for an Integrated Monitoring and Research Framework for the Mid-Atlantic Region. If the implementation of this Regional Framework does not produce information which can improve the effectiveness of protection and management activities which address these issues, it will not be perceived as relevant, not provide incentives for adaptation of existing monitoring programs, and ultimately not be embraced and sustained.

Changes in Land Use and Cover: What are the changes in land use and land cover and the consequences of these changes to biotic and abiotic resources and the quality of human life?

> The Mid-Atlantic Region is characterized by extensive forests and agricultural lands and also by substantial urban and suburban development which is expanding three-times faster than the population is growing. Food and fiber production, wildlife resources, biodiversity, water quality, and human quality of life and recreation are all affected by the dynamic changes in land use and cover in the region.
>
> Important management goals in the region (no priority order implied) include: (1) urban/suburban growth management (which has important implications for infrastructure costs, social goals, and quality of life as well as air, water and soil quality and habitat conservation); (2) agricultural land preservation; and (3) maintenance of healthy forests (for sustainable use of resources, conservation of biological resources, and maintenance of water quality).

Nutrient Over-enrichment: What are the sources and transport rates of nutrients (particularly nitrogen and phosphorus) and the effects of increased nutrient loading on terrestrial, aquatic and marine ecosystems? To what extent are control strategies effective?

The Mid-Atlantic Region is characterized by large inputs of plant nutrients from agriculture, food consumption, waste disposal and the combustion of fossil fuels and by extensive estuaries with long residence times. It is also characterized by activities (urban development, agriculture, and deforestation) which diminish the nutrient-retentive capacities of the landscape. This is an explosive mixture which has resulted in eutrophication of some rivers and lakes and virtually all of the estuaries in the region (and possibly even continental shelf waters) with undesirable consequences to resources. Reduction of eutrophication via nutrient control strategies throughout the watersheds is a central objective of the ambitious ecosystem management efforts in Chesapeake Bay, the Albemarle-Pamlico Sound system, the New York City water supply and elsewhere. A new monitoring framework that does not enhance our capability for assessing atmospheric inputs, landscape conditions and hydrological processes affecting nutrient transport, and the responses of aquatic and coastal ecosystems is not likely to be embraced by the important regional management programs that focus on nutrient control.

Water Resources: What are the present status and future trends in the quantity and quality of water for human use?

Population growth and sprawl and the use of freshwater resources for agriculture and industry are placing increasing pressures on this "water-rich" region. Groundwater draw down and contamination (e.g. with nitrate) and water-use conflicts in water-limited areas where rapid development is taking place (e.g. urban southeastern Virginia) are harbingers of problems to be faced in the future elsewhere.

Air Quality and Atmospheric Deposition : What are the status and trends of air quality and the deposition of nutrients and toxicants from the atmosphere? What are the effects of emission control strategies?

The atmosphere throughout the region is modified by human activities, particularly by changes in its chemical composition as a result of combustion of fossil fuels, not only those activities within the region but by activities in the broader "airshed." Human respiratory problems and stress to forests caused by increased ground-level ozone; increased haze; acidic deposition with resulting effects on soils, forests, streams and lakes; and eutrophication aggravated by deposition of nitrogen are among the consequences. The atmospheric sources are now known to be a significant source of nitrogen and certain toxicants in parts of the region.

Stream and Wetland Habitat Prot ection and Restoration : What are the extent and nature of stream and wetland habitats, how have their functions been impaired, and how effective are efforts to protect and restore them?

The streams, rivers, and wetlands throughout the multiple watersheds of the Mid-Atlantic region function as the circulatory system—and to a large extent the kidneys—of regional ecosystems. These habitats have been significantly degraded by sedimentation, acid mine drainage, and modification of riparian zones, impairing their hydrologic, assimilatory and habitat functions. Protection and restoration of streams and wetlands are common goals

throughout the region, be it for fish and wildlife, recreation, or nonpoint source control. Integrated monitoring in the region should contribute to assessments of the most effective protection and restoration strategies and of progress toward management goals throughout the region.

Coastal Fisheries Resources: What is the status of coastal fishery resources and how can depleted resources be rebuilt and sustained?

Coastal fisheries are in trouble throughout the Mid-Atlantic region as a result of unsustainable utilization, obstructions to migration, habitat degradation and diseases. Major efforts are underway, ranging from restoration of stream access by anadromous species to rebuilding oyster reefs to severe restrictions of harvest, in order to rebuild stocks and manage sustainable use. These efforts involve Federal and state agencies and private and non-governmental organizations. Although fisheries management issues are important in many other regions of the country, the interconnectedness of coastal ocean, estuarine and riverine habitats and populations is an important characteristic in the Mid-Atlantic which poses particular requirements for integrated environmental monitoring.

Urban Environmental Quality and Human Health : What are the exposure conditions of urban and nearby populations to important environmental health risks?

While the Mid-Atlantic Region provides a relatively healthy environment for its millions of residents, concerns about the environmental effects on human health remain in specific parts of the region, particularly in urban and surrounding regions. Of particular concern are ground-level ozone, not only in cities but in suburban and rural areas downwind, and exposure to toxic substances and environmentally borne pathogens for urban populations whose socio-economic circumstances present greater risks.

5. Opportunities and Needs

Four media-specific groups identified ongoing local, regional and national monitoring programs for the atmosphere and terrestrial, freshwater, and coastal environments, using the Reference Issues as a touchstone of relevance. A fifth group addressed regional synthesis, specifically identifying the current state of integration across environmental media and useful models and management strategies that could foster integration. All groups were also asked to identify significant gaps in environmental monitoring and related research and opportunities for better integration of monitoring programs and consider the current state of environmental research in the region.

Table 1. Atmospheric monitoring programs which could contribute to integrated monitoring in the Mid-Atlantic region. See Appendix 3 for list of abbreviation s and acronyms and Appendix 4 for an inventory of major federal environmenta l monitoring and research networks and programs .

Program	Deposition		Air		Visibility
	Wet	Dry	O_3	(SO_x, NO_x)	
NADP	weekly				
AIRMoN wet	daily				
AIRMoN dry		hourly-weekly		weekly	
CASTNet		weekly	hourly	weekly	
NARSTO/PAMS			hourly	hourly	
NPS				hourly	
IMPROVE				daily	hourly
STATES (NAMS/SLAMS)					

The Atmosphere

Monitoring of atmospheric variables is important for assessment of a number of the Reference

Issues for the Mid-Atlantic region. These variables include wet and dry deposition of nutrients and toxics; ambient air quality (O_3, SO_2, NO_x, chlorinated organics, and organic particles); atmospheric emissions (SO_2, NO_x, VOC, toxics, and greenhouse gases); and meteorological data. These indicators should be considered in terms of their spatial and temporal variations, loadings, and concentrations. Ongoing monitoring programs range from compliance monitoring required by the States to national and regional networks that address deposition, air quality and visibility as summarized in Table 1.

The breadth of issues addressed by the atmospheric monitoring activity extends across the spectrum from ecology to health and to aesthetics, correlating strongly with the tabular headings deposition, concentration and visibility in Table 1.

The priority environmental issue for atmospheric monitoring in the Mid-Atlantic region is ozone and its consequences. It affects both human health and ecosystems via direct effects on vegetation and indirectly via its relationship to the deposition of oxidized nitrogen (NO_x), which contributes to acidity and excess nitrogen loading of terrestrial, aquatic and coastal systems. The factors responsible for ozone formation thus also influence acid deposition, eutrophication and air borne particles which affect human health and aesthetics. This is one inter-related system which has to be dealt with simultaneously. A second issue concerns the integration and assessment of the effectiveness of air quality regulations with respect to human and ecosystem health. Questions raised include the following: What is the health of the ecosystem and how is it changing (a monitoring and research issue)? Why is it changing and what is causing the changes (a source quantification and research issue)? What can be done about undesirable changes (an assessment issue)? And, is the action taken having the desired effect (a monitoring issue)?

Gaps and research needs identified include the following:

the ability to accurately quantify point estimates of dry deposition versus that of wet deposition, especially in complex terrain;

the ability to accurately quantify dry deposition at a given point;

the ability to predict wet and dry deposition by interpolation or extrapolation, which requires better models;

integration of data from rural and urban monitoring sites, including determination of the effects of urban sources on rural areas;

refined estimates of emissions (SO_2, NO_x, plus C_2O, CFCs, etc.) from both natural and anthropogenic sources and how these sources vary across the region and temporally;

quality control for state-run toxics monitoring;

timely integration between modeling and monitoring; and

measurements of atmospheric conditions over open coastal waters.

Regarding other elements of the Framework, the selection of Index Sites should be influenced by the regional Reference Issues and and the appropriateness of the sites for testing hypotheses as well as by ecoregion considerations. However, the focus on intense measurement at Index Sites should not come at the expense of the number of valuable monitoring sites already in existence. Co-location of Index Sites with existing sites should be considered when existing sites provide the regional representation required.

One of the objectives in the initial phases of the program is to characterize the amount of variability in measurements among sites and determine the optimal number of sites required to deliver the needed level of certainty from the data.

Reductions in the number of monitoring sites generally imposes greater reliance on modeling predictions for interpolating and extrapolating measurements. But, models currently require more observations in order to increase confidence in their predictions. Surveys, or synoptic measurements over large areas, are not very relevant in atmospheric monitoring. Rather, monitoring of highly dynamic atmospheric conditions require long-term observations at fixed locations.

Finally, the Mid-Atlantic region is influenced by atmospheric sources and processes from outside of the region itself. The "airsheds" are much larger than the watersheds. For this and other reasons, ambient air and meteorological measurements are necessary for the interpretation of modeling results and are critical for integrating environmental management concerns.

Terrestrial Environments

Integrated monitoring of terrestrial environments in the Mid-Atlantic region must consider:

Land use and management, which affects ecosystem goods and services, environmental quality, and the sustainability of any given use. Management, planning, and analysis of effects must take into account interacting components of landscape structures and processes, including coverage type and area, intensity of use, structure of the biotic and abiotic environment, and the spatial extent and distribution of different land use types.

Human activities, which have become the primary short-term driver of natural ecosystem structure, process and stability in the Mid-Atlantic region. At the same time, We must also consider the impacts of the natural ecosystem on the condition of the human economic and social systems. Issues which are particularly relevant in that regard include links and feedbacks between human and natural systems (ranging from public health and recreation to species preservation); economics and sustainable resource use; social priorities; human demographics; hydrologic functions, including water resources and water purification functions; ecosystem sustainability, health, and production; and climate change (increasing CO_2 and changing temperature and precipitation).

A variety of local, regional and national monitoring and assessment activities that are relevant to integrated monitoring in the Mid-Atlantic region were identified. Only some of these of larger scope are listed below (see also Appendix 4). From this listing it is clear that there is much monitoring of terrestrial environments in the Mid-Atlantic, but the monitoring is generally conducted for a particular assessment purpose and the programs are poorly linked.

. Multi-Resource Land Characterization (MRLC) involves collection and analysis of remotely sensed data from Landsat Thematic Mapper (TM) and Multi-spectral Scanner (MSS) coordinated by EPA. Its objective is the reporting of changes in land cover. At present it has no formal link to assessments, remains to be adequately ground truthed, and is not calibrated to State efforts.

- USGS Land Cover Mapping involves collection and analysis of remotely sensed data via AVHRR. Its objective is to identify ecotype complexity. This program is not linked to any planned assessment activity or to state or local efforts. Ground truthing is in its infancy.

- Southern Appalachian Assessment employs data from TM, Forest Inventory and Analysis and the Heritage Program for the purpose of specific assessments. It covers three mountainous counties in Virginia and West Virginia and involves cooperation with the Man and the Biosphere (MAB) Project in cooperation with states and the United States Forest Service. Its objectives are to assess land-use fragmentation, forest health and species diversity. There is a socio-economic component linking human population growth, demographics and recreation needs to the environmental component.

- State Gap Analysis Programs (GAP) are assessment-driven and involve cooperation among the National Biological Service, States and State heritage programs. Their objective is to examine the distribution of species and habitat, asking the question: "Do conservation programs actually protect species?" They employ TM and aerial videography and are linked to on-the-ground biodiversity surveys.

- Forest Health Monitoring Program (FHM) coverage includes 20 states nationwide, including Delaware, Maryland, Virginia, West Virginia and New Jersey in the Mid-Atlantic. Based on a state-Federal partnership, its objective is to assess forest health. In this program aerial photography is linked to plot-based sampling conducted by the states and the U.S. Forest Service. Data collection is underway and an quality assurance/quality control program is in place. An assessment framework is under development and a few assessments have been recently completed.

- Coastal-Change Analysis Program (C-CAP) is conducted by NOAA and has as its objective the quantification of coastal habitat change on approximately five-year intervals. LandSat TM is used to measure changes in emergent wetlands and coastal upland vegetation and aerial photography is used to measure changes in submersed aquatic vegetation. Much of the ground verification is provided by cooperating state agencies. C-CAP is initiating a second change detection for the Chesapeake Bay estuarine drainage area for the period 1989-1994.

- Baltimore-Washington Collaboratory has the objective of providing a spatial data framework to calibrate and assess landscape change models. Its approach includes the development of ground truth data and historical analysis of land use. The assessment objective is to determine and improve the quality of resource assessments for use in water quality, land-use, and water-use planning in the Baltimore-Washington area.

- National Resources Inventory of the U.S. Department of Agriculture has the objective of determining the linkages between land management, land cover, commodity production, water quality, and soil quality. It includes private lands surveys and provides “ground observation” as opposed to ground truth. There are no formal linkages to other media or

land ownership surveys and associated assessments have been driven by Congressional mandate.

Important needs for improving the ability to monitor, assess and report on changes in terrestrial environments in the Mid-Atlantic region include the following:

accurate information on the changes in land use, both in terms of their spatial dimensions and intensity of management;

measurements of changes and events at the "edges" between land uses and ecozones where dynamic changes make establishment of “stable” measurement sites difficult; .

sufficient coverage atmospheric deposition monitoring sites to link deposition to response;

quantitative soil surveys, based on proabalistic sampling and updated frequently enough to keep abreast of changing soil conditions;

integration of sampling, sampling protocols, data sets and analysis and assessment efforts to determine cause-effect relationships;

the capability to project the impacts of economic and demographic changes on terrestrial ecosystems;

regional assessments of net primary productivity and CO_2 flux;

adequate characterization of watershed hydrology;

a disease information system (plant, animal, human);

coordinated information on the status and trends of exotic species;

an assessment framework including community ecology, biodiversity, and interaction dynamics as they affect nutrient cycling, disease, species survival, etc.

The following would help meet these needs:

1. Data and information on why private land managers make the decisions they do.
2. Information distribution systems that are responsive to user needs.
3. Techniques for the interpretation of urban imagery.
4. Integrated reference information that provides more complete coverage (including Index Sites and integrated surveys).
5. Integration tools (conceptual and assessment models) that define expectations of ecosystem goods and services. These should codify, in terms usable by multiple perspectives (environmentalists, extraction companies, municipal management commissions, game management agencies, etc.), what is meant by "healthy” ecosystems,

forests or fisheries.

6. Indicators for use in integration models that reflect ecosystem condition, distinguish changes from normal variability; and are logistically feasible and cost efficient.
7. Methods (statistics, empirical and conceptual models, valuation techniques, etc.) to aggregate measurements into indicator indices.
8. Approaches to compare transfer effects between different systems.
9. Improved techniques for the measurement of CO_2 flux and the linkage between flux and ecosystem net primary productivity.
10. Methods for more complete and simple characterizations of watershed hydrologic framework (source, routing, timing).
11. New techniques for organismal profiles that incorporate the population dynamics and functional roles in the ecosystem of the organism.

Aquatic Environments

Consideration of a series of questions concerning aquatic environments and resources is helpful in assessing the potential contributions of existing programs to an integrated regional monitoring program and the gaps which need to be filled:

. Aquatic organisms, including non-indigenous species:

Are populations of aquatic organisms and water-dependent reptiles and mammals changing? Where have changes occurred and why have they occurred (e.g., UV-B, acid rain, agricultural runoff, endocrine disruption)?

Are management practices and regulations having their intended effects?

. Stream habitat and substrate alterations:

Are flows adequate to support fisheries and benthic invertebrates?

Which human activities have affected aquatic habitats and to what extent?

What are the effects of wetlands loss, channelization, impoundments and subsidence?

Are management practices having the intended effect?

. Hydrology and water supply:

Have water supplies, distributions, and runoff characteristics changed due to water use (urban development, land use, salt-water intrusion)? Where and why have changes occurred? How might they change in the future, particularly as a consequence of climate changes?

Are water supplies adequate to serve future populations?

. Water quality:

How has water quality in surface and sub-surface waters changed? Where have changes occurred and why have they occurred (land use, climate change, land fills)?

Have management practices had the intended effect?

What factors control or influence water quality (e.g., sedimentation, acidification, eutrophication including trophic status, acid mine drainage, salt-water intrusion, geology)?

. Wetlands and riparian zones:

Are wetlands in the region continuing to change?

Where have the changes occurred and why have they occurred (e.g., land use, climate change, restoration, waste treatment)?

Have management practices had the intended effects?

What factors control or influence wetland function? Do wetlands provide functional values for downstream water quality, stormflow attenuation, and sediment control? Have those functional values changed over time (e.g. as a result of physical, thermal or chemical effects)?

To what degree do artificial and restored wetlands provide the functional values of natural wetlands?

. Impoundments:

What is the current distribution of free-flowing streams?

What have been the effects on downstream water quality, flows, ecology, etc?

Have reservoirs been properly maintained?

What changes have occurred in the reservoirs themselves?

. Storm-water management

Has stormflow runoff in surface and sub-surface waters in the region changed?

Where have the changes occurred and why have they occurred (e.g., land use, climate change)?

Have management practices had intended effects?

What factors control or influence stormwater (sedimentation, decreased impervious surfaces, agriculture, eutrophication including trophic status, acid mine drainage)?

. Historic preservation and esthetics:

Have the socially-valued aspects of our wild and scenic rivers changed?

With this background of questions, performance-based tests can then be applied for any efforts to monitoring freshwater ecosystems. Defining such performance measures should be a high priority early in the Regional Pilot planning process. The following list of performance measures may turn out to be appropriate for any environmental medium and could be applied after the first two years of implementation and subsequently:

test of the concept across scales using existing data, i.e., a preliminary assessment;

a demonstrable effect of the Framework on policy;

examples of increased efficiency and successful collaboration;

examples of integration across scales that improves understanding;

significantly increased accessibility to data;

increased public awareness; and

effective participation by the research community.

In addition to the monitoring programs that have been included in the inventory of major federal environmental monitoring and research networks and programs (Appendix 4), the following potential contributory programs were identified as potential contributors to integrated monitoring in the Mid-Atlantic: Shenandoah SWAS, VTSSS, New York City water quality information system, Otter Creek/Dolly Sodds and the USGS ground water network.

In consideration of what is missing from the current array of monitoring programs of aquatic environments it was first noted that a thorough and critical assessment of the current state of understanding should be a high priority. Generation of existing data has not been sufficiently hypothesis-driven and such an assessment is required for effective design of future monitoring networks within the integrated regional and national frameworks. In addition, approaches should be kept simple (bigger is not necessarily better). Beyond these admonitions, the following needs were identified:

- Multi-media index areas to evaluate the relationship of atmospheric processes, terrestrial ecosystems and aquatic ecosystems.
- Nested watershed monitoring stations that help address important scale issues.
- Sites representing the range of relevant conditions operable for specific environmental issues, particularly sites providing opportunities for monitoring along gradients of exposure and tolerance.
- Research on quantification of change and how change affects ecological function.
- Modeling and integration tools which allow spatial extrapolation.

. Networks for integrating index site and survey-based measurements.

. Assessments of the comparability of databases in a test watershed.

Coastal Environments

The Mid-Atlantic region contains some of the nation's largest estuarine ecosystems, including Delaware Bay, Chesapeake Bay, and the Albemarle-Pamlico Sound system, as well as several smaller coastal lagoon systems along the Delmarva Peninsula. All of these estuarine ecosystems are heavily influenced by activities and processes in the watersheds which drain into them. They are thus linked with most of the Mid-Atlantic region as defined here, except for those portions of Virginia, West Virginia, Maryland and Pennsylvania which drain into the Ohio and Tennessee basins and ultimately into the Gulf of Mexico. Similarly, these large estuarine ecosystems are intimately tied to the coastal ocean of the Mid-Atlantic Bight, extending across the continental shelf. This relationship with the coastal ocean is not only via tidal influence and the supply of salt water, but also is influenced by the migration and passive movement of organisms between estuaries and the coastal ocean. For these reasons, it is important that integrated monitoring and research within the region encompass the coastal ocean, estuaries and watersheds of the region. Many existing programs could contribute to integrated monitoring in the Mid-Atlantic region. A partial list is given in Table 2.

Of the reference issues for the Mid-Atlantic (Section 4) all have direct or indirect consequences in coastal environments of the region. Even those that appear to focus on land (Changes in Land Use and Cover), the atmosphere (Air Quality and Atmospheric Deposition) and freshwater environments (Stream Habitat Protection and Restoration) affect the delivery of materials to estuaries and the coastal zone and are now major focal issues for estuarine restoration in the region. However, two of these issues are of particularly direct and widespread relevance to coastal environments of the region: Nutrient Over-enrichment and Coastal Fisheries Resources. The monitoring and research programs which could contribute to regional coastal assessments related to these two Reference Issues were considered in depth in the Workshop. Other issues are, nonetheless, also important in at least some parts of the Mid-Atlantic coastal zone. For example, major urban areas such as Philadelphia, Baltimore, Washington, and Hampton Roads are located on estuaries, where exposure of humans (as well as estuarine organisms) to toxicants and pathogens is of significant concern. In addition, the coastal ecosystems of the region may be particularly vulnerable to climate change as it affects not only ambient temperatures, but also sea level rise, freshwater inflows and coastal

Table 2. Monitoring and research programs relevant to coastal environments which could contribute to a Mid-Atlantic Integrated Environmental Monitoring Program. Names and descriptions of major federal programs (abbreviated) are provided in Appendix 4.

Agency	Programs

NOAA	C-CAP, NS&T, COP (including Chesapeake Bay cumulative effects research), CBOS, Chesapeake Bay Research Program (environmental effects, remote sensing, stock assessment), NWS, NBP, NERR, PANDA, SEAMAP/MARMAP, Coast Watch
Interior	GAP, NWI, NAWQA, NASQAN, NADP, NPS Ecological Monitoring Program
EPA	EMAP, CBP, CASTNet, NAMS/SLAMS,
Energy	Ocean Margins Program (off Cape Hatteras)
NSF	LTER (Coastal Virginia), LMER (Chesapeake Bay)
Smithsonian Institution	SERC long-term research on Rhode River and other watersheds
Army Corps of Engineers	District Office programs, Coastal Environmental Research Center (Duck, NC), water level network
CIA	Global Fiducial Monitoring
NASA	various remote sensing activities based at Goddard, Langley, Wallops Island
States	water quality, pathogen and living resource monitoring

storms. An assessment of priorities for research, monitoring and modeling to address key coastal environmental quality issues has been provided by the NRC (1994).

Nutrient Over-enrichment: Over-enrichment of coastal ecosystems with nitrogen (N) and phosphorus (P) is a concern throughout the Mid-Atlantic region, but is manifest in different ways as a result of great physiographic differences among the estuaries within the region. Delaware Bay is an open system and is well flushed. Nutrient over-enrichment with P is mainly a problem in the upper reaches of the estuary. The Chesapeake Bay is also an open coastal plain estuary, but its lower flushing rates, reduced tidal energies, and physiography allow greater nutrient retention, thus more severe consequences of eutrophication (by both N and P inputs). The Albemarle and Pamlico Sounds are lagoons with very restricted tidal exchange and, although shallow, are susceptible to algal blooms and episodic hypoxia. The Delmarva coastal bays are also lagoons, but are open to exchange with the ocean to varying degrees. Consequently, they vary in their susceptibility to eutrophication. There is also concern that the continental shelf waters of the Mid-Atlantic Bight are also enriched with nutrients escaping from the estuaries or falling in the form of atmospheric deposition.

Table 3. Status of understanding and addressing eutrophication in Mid-Atlantic coastal ecosystems.

Key Question	Chesapeake Bay	Albemarle-Pamlico Sound	Delaware Bay	Coastal Bays	Coastal Ocean
How extensive?	known	partly known	known	partly known	poorly known
Getting better or worse?	decreased P, increased submersed aquatic vegetation	unknown, need monitoring program	increased oxygen in upper estuary	varies among bays	unknown but loadings have increased
Causes?	reasonably well known; atmospheric & ground-water inputs little known	partly known	organic loading in upper estuary; nutrient loadings to coastal ocean?	preliminary models available	new ocean color and atmospheric deposition measurements will help
Know solutions?	reduce point and nonpoint sources of nutrients	effectiveness of agricultural non-point source control?	reduce BOD	varies; nonpoint sources and atmosphere important	Requires regional coordination, focused program
Effectiveness in reducing?	partly, effectiveness of nonpoint source controls?	unknown, management plan not yet implemented	improved DO, fisheries following BOD reductions	unknown, plans under development	not attempted

Table 3 presents a comparison of present understanding of eutrophication, or nutrient-overenrichment, and efforts to control it in Mid-Atlantic coastal ecosystems. Responses to nutrient inputs, completeness of understanding of the trends, causes and solutions, and progress of control strategies clearly vary greatly among these ecosystems. As exemplified in the Chesapeake Bay, integrated monitoring and research, can make significant contributions in identifying management strategies and judging their effectiveness. Although the coastal ecosystems of the region vary in terms of their physical and ecological characteristics and sources of nutrients and monitoring requirements vary accordingly; a regional Framework for integrated

monitoring, modeling and research would allow greater comparability, synthesis of applicable results, and extension of management approaches.

In contrast to other important environmental issues in coastal ecosystems such as habitat change, toxic contamination, or living resources, monitoring of environmental characteristics pertinent to eutrophication cannot easily be done by periodic inventories and surveys. Parameters which reflect responses to nutrient enrichment, including nutrient levels, phytoplankton biomass and community structure, and dissolved oxygen are temporally highly variable and are poorly characterized by yearly, monthly, or in some cases even weekly surveys. In addition it is important to monitor rate processes (production, flux, etc.) and physical forcing functions (currents, mixing, etc.) as well as state variables (concentrations, population density, biomass, cover, etc.). Consequently, there is a particular need to include more near-continuous, *in situ* measurements of both state and process variables in monitoring of eutrophication effects. For example, the Chesapeake Bay Observing System (a series of permanent buoys equipped with a variety of environmental sensors being deployed via a partnership among regional universities, NOAA and other federal agencies) offers a promising approach for monitoring dynamic environmental conditions in coastal ecosystems. Also, integration of monitoring and research is particularly critical for assessments of coastal eutrophication. The Chesapeake Bay Program has been a particularly effective test bed for such integration and that experience could be extended to other coastal ecosystems in the region and nationally.

Coastal Fisheries Resources: Management, sustainable harvest, restoration and habitat requirements of coastal fisheries resources are of wide-spread concern throughout the Mid-Atlantic region. Parameters which are monitored for various stocks include catch, fishing effort, bioprofiles which assess growth and reproductive maturity, age-specific harvesting mortality, and bycatch (i.e. non-target species which are captured in the harvesting process). These data are used to develop population assessements and estimates of spawning stocks. Coupled with knowledge of natural mortality and the physical, habitat, and biological (e.g. predation and disease) factors which affect mortality, these inputs are needed for models which predict sustainable harvest levels. Defining the sustainability of coastal fisheries resources is a challenge throughout the Mid-Atlantic region. Federal, regional and State management systems are in place, but frequently are relegated to "playing catch-up" in managing the resource, particularly for species which have not yet been well studied or for which exploitation is expanding. Even when catch statistics or fishery-independent sampling and assessment indicate overfishing, economic and political considerations may prevent harvest restrictions needed to maintain stocks.

Monitoring of fishery stocks can indicate if they are declining, but there is usually a high degree of uncertainty associated with such estimates. Furthermore, it is also important to determine what may be causing the decline, but the complexity and variability of population-environment-harvest relationships make this difficult to accomplish. Without good knowledge of the variability of environmental conditions and the resulting effect on fishery populations, there is a risk that harvest restrictions imposed because of declining populations may have no

effect on sustaining the resource. Nonetheless, continued monitoring of catches and populations can be useful in determining whether management strategies have been effective in conserving the resource.

Much of the monitoring data produced on coastal fisheries is generated by state agencies, which generally lack effective mandatory catch reporting systems. Consequently, it is difficult to obtain accurate catch-per-unit-effort data and assessments tend to be reactive, rather than proactive, in meeting management needs. Furthermore, there are generally poor data on recreational catches and effort. Programs need to be institutionalized and better coordinated in order to achieve an integrated research, monitoring, and assessment system for coastal fisheries.

International Linkages: The Mid-Atlantic region is arguably the world leader in monitoring and research in coastal ecosystems because of the presence of three large estuarine systems and an unparalleled concentration of university research institutions which emphasize coastal research. An important dimension of a Mid-Atlantic Integrated Monitoring Framework should, therefore, be innovative contribution to monitoring globally relevant phenomena in the coastal zone (sea level, changes in runoff and the flux of biologically important materials, etc.). Although the present monitoring effort and any new ones that develop under this Framework should, first and foremost, address domestic environmental issues, they should also be a linked component of the emerging Global Ocean Observing System (GOOS). By combining cutting-edge remote sensing and in situ measurement technology with the intensive conventional monitoring, the Mid-Atlantic should be a world leader in Coastal GOOS.

Regional Synthesis

The breakout group defined regional synthesis as: "deliberate planning of environmental monitoring and research to allow integration and assessment across spatial, temporal, media and institutional units." It is clear that most of the Reference Issues identified for the Mid-Atlantic Region (Section 4) affect multiple media and require a synthesis approach for assessment of problems or solutions, e.g. Land Use and Cover, Atmospheric Condition and Deposition, Nutrient Over-enrichment, and Coastal Fisheries Resources.

For example, coastal fisheries are impacted by land use, soil destabilization, coastal habitat loss, and water quality. Furthermore, fish populations may be influenced by the conditions of the different environments through which they migrate. Although there are significant amounts of data on both the resources and driving environmental factors, combining these data to predict outcomes is problematic. In order to bridge the gap between fisheries management needs and water quality monitoring and environmental research, the Chesapeake Bay Program is developing an ecosystem model to link environmental processes and conditions across environmental media to living resource production in the Bay.

It is important to remember that the Integrated Monitoring Framework cannot be simply a network of intensive monitoring and research sites (i.e., Index Sites). Rather it is based on the integration and interdependence among these intensive activities and broader resource surveys,

inventories and remote sensing programs (NSTC, 1996). Surveys and inventories that provide continuous coverage, such as those done by satellite or aircraft remote sensing, are particularly useful for regional synthesis. Land-use and vegetation characteristics are relatively well covered for the region and coordination and integration among programs such as C-CAP, NAWQA, and FIA (see Appendix 3 for list of abbreviations) are proceeding, although formal integration across spatial and temporal scales is hindered by methodological differences and the lack of common models of multi-stress interactions. Additional effort is now needed in ground truthing to verify and inter-relate existing remotely sensed information. There is, however, limited spatially continuous coverage of environmental properties of coastal ecosystems. For example, maps of nearshore or coastal ocean topography (bathymetry), bottom-type, and sediment-type analogous to those of terrestrial properties do not exist. Gaps in continuous spatial coverage of environmental characteristics, such as bottom substrate properties, could be filled by employing new techniques (e.g., side-scan sonar) which now make spatially continuous information relatively easy to collect. Focused and coordinated efforts by COE, NOAA and USGS would help accomplish this.

From another aspect, integration of biotic surveys and inventories across taxonomic groups (or within taxonomic groups among different monitoring efforts) is weak or non-existent and should be improved. Notable exceptions are birds and some coastal fishes. For many taxa and environments our present ability to monitor and assess status and trends in biodiversity is extremely limited. Deliberate and concerted planning of biodiversity monitoring is needed across spatial and temporal scales and among institutions.

Also, access to some important data sets is restricted; however, opportunities to increase use of such restricted information are emerging:

> for the Forest Inventory and Analysis the possibility exists for potential users to ask questions about trends without accessing the data (which are restricted under the terms of agreement with private property owners); and
>
> there is a slowly growing opportunity to gain access to previously restricted data gathered by military and intelligence satellite assets.

A particularly useful integrating framework for synthetic assessments using monitoring data are ecological cycles or models. These include the hydrologic cycle, nutrient cycles, and biogeochemical and mass balance approaches. The hydrologic cycle, in particular, is useful in evaluating and integrating monitoring, research and assessment within watersheds. Following water and the materials associated with it through the watershed to the estuary provides an opportunity to determine where existing monitoring and research can contribute to assessments, where there are gaps in information or understanding, and where modification of monitoring and better integration would yield improved results. The development of the linked Chesapeake Bay atmosphere-watershed-Bay models provide an advanced example of this approach toward regional integration. Interestingly though, although the models are reasonably well developed, efforts to integrate the various monitoring activities (land use, deposition, stream flux, water

quality, living resources) associated with the CBP are just being launched in the development of a strategic monitoring framework. This provides a timely opportunity for joint planning and implementation between the CBP and the CENR Mid-Atlantic Regional Pilot.

Another approach to regional synthesis involves the comparison of distributions of various environmental indicators over space or time without explicit functional linkage among them. This is essentially the approach used in EPA Region III's Mid-Atlantic Integrated Assessment (MAIA), which includes extensive use of data from the Environmental Monitoring and Assessment Program (EMAP) as well as other sources. For example, land-use patterns are compared to stream health indicators and inferences drawn about relationships. The ideal framework for synthesis combines spatial analyses such as these with process models of flows and functional interactions. Spatially explicit functional models have been developed for the Patuxent River estuary and watershed in the Chesapeake Bay region (Bockstael et al., 1995) which are now incorporating socioeconomic patterns and processes as well as biophysical ones. These models will ultimately allow one to address the consequences of location-specific changes (e.g., changes in land-cover or land-use) to ecosystem functions, goods and services (e.g. nutrient flux).

6. Functional Implementation

Concurrent breakout groups addressed various aspects of the implementation of a Mid-Atlantic Pilot Integrated Monitoring Program. They had as guidance the National Framework and the Mid-Atlantic Reference Issues and used the previous deliberations on Opportunities and Needs as input. Their goal was to identify implementation strategies and actions to better integrate ongoing monitoring and research efforts into an effective regional framework, asking the questions: What changes would reduce barriers to integration? What are the benefits and risks of integration? To what degree are existing programs adaptable for achieving better integration? Where are investments needed to fill critical gaps or build required networks? What steps need to be taken now and where should we strive to be in five years? By what criteria should performance be judged?

Integration and Coordination of Monitoring Programs

A major challenge to the implementation of integrated environmental monitoring, whether it be for the nation, a region, or even locally, is the adaptation, linkage and coordination of the component elements (across agency lines, media and scales). It is helpful, then, to examine some examples where there has been deliberate integration of monitoring programs and monitoring needs as potentially useful models. Those considered during the Workshop include NARSTO-Northeast and SOS for air monitoring, the Interagency Task Force for Monitoring of Water Quality (ITFM) for water monitoring, and Multi-Resolution Land Characteristics (MRLC) for land cover. Obstacles to greater and more effective coordination and integration of monitoring programs include personalities, money (lack of or too much), management barriers and inflexibility, insularity of the technical communities, statutory constraints, and lack of commitment or dependability.

Several dimensions of integration are relevant and need to be articulated in the interest of clear communication:

Ecosystem integration involves the conceptual linkage and coordination of monitoring of different media and resources within an ecosystem. Examples include relating measurements of water quality, concentrations of toxicants and living resources or measurements of atmospheric deposition, soil chemistry, stream transport and ecosystem responses. Ecosystem integration requires (a) the availability of relevant scalable data; (b) models that extend to the full range of ecosystem questions; and (c) technology that matches the resource base and the data needs.

Spatial integration involves the linkage of measurements made at different spatial scales and comparisons among different ecosystems and regions. It requires (a) measurement and research programs conducted at intercomparable scales; (b) interpolation techniques to integrate scalar data; (c) data management capabilities to manage multi-scale data; and (d) conceptual understanding of scalar ecological processes. Therefore, an effective monitoring framework must integrate data from a broad range of ecosystem scales.

Temporal integration involves linkage of measurements made over different time scales and

must take into account the different characteristic time scales of variation among ecosystem properties and processes and among different ecosystem types. Using stream flow as an example, how does one integrate measurements of short-term events, mean monthly flows, interannual variations, and long-term hydrologic and climatic trends, any of which may be the most important depending on the question asked. Temporal integration requires: (a) data management techniques for appropriate archives; (b) clear articulation of issues of concern; (c) periodic and timely production of information; (d) long-term commitment; and (e) measurement and research programs bridging temporal scales at common sites or areas. .

In addition, other essential dimensions of integration must be addressed, including:

institutional issues affecting communications, missions, authorities, and resources;

data and information, including management, access, standards, and archiving; and

quality assurance and quality control.

Finally, the following steps must be undertaken towards the goal of program integration:

- Identify and clearly articulate the issues and needs, including consideration of which methods and measurements are mandated versus which can be adjusted slightly. This step also implies that deliberate discussions are occurring between programs that have identified a common opportunity.
- Analyze and evaluate existing programs and data resources.
- Identify the gaps, overlaps and specific opportunities for integration.
- Design the required monitoring.

Within the above steps, effective communication systems need to be in place; stakeholders and partners need to be involved and educated; resources for effective coordination (people, and funding) need to be committed to the effort; mechanisms must be instituted to support integration; and both top-down and bottom-up independent reviews should be periodically conducted.

An important opportunity exists for the Mid-Atlantic Pilot to work synergistically with the Chesapeake Bay Program (CBP) toward the integration and coordination of monitoring programs. Up to this point, the extensive monitoring efforts used within the region have been implemented and interpreted in a fragmented manner. For example, the CBP Implementation Committee is embarking on a strategic plan for monitoring with a key emphasis on achieving more effective integration of monitoring of estuarine water quality, living resources, riverine fluxes, land use/cover and atmospheric deposition. The CBP has the advantage, not only of very extensive monitoring efforts, but also management-oriented models which integrate among the environmental media which can be used in assessing critical monitoring needs and linkages. The CBP effort could help to significantly advance the integration of monitoring throughout the region. Conversely, the Mid-Atlantic Pilot could stimulate and assist the strategic integration of CBP monitoring activities and those of other regional assessments such as the Mid-Atlantic

Integrated Assessment (MAIA) and the Mid-Atlantic Highlands Integrated Assessment (MAHA).

Integration of Research and Monitoring

Implementation of the Environmental Monitoring and Research Framework should advance research to understand ecosystem processes relevant to environmental change in the following ways:

- Current programs have scale problems. Most studies are less than two years long, consider only one or two species as indicators, and are limited in spatial scale. Studies that address multiple species are usually limited to relatively small spatial scales. There is a need to be able to integrate and extend results over a range of scales, small to large, short-term to long-term, and limited to inclusive. Several opportunities are provided in the Integrated Framework. The nested watershed concept of Index Sites provides a useful way to relate intensive research in a small watershed to larger scale processes. Longer term or more spatially extensive data from monitoring programs can provide critical background for interpreting the results of shorter term or more localized research.

- Some current monitoring programs are long-term but they need better ways of disseminating data to users, more systematization of units (interoperability), and ways to move new technologies into operational monitoring programs (flexibility and adaptability to emerging technologies). Time is needed to plan and test new methods against the old and then assess the appropriateness of bringing them on line. For example, incorporation of new methods throughout the LTER network requires about 2-2½ years to come to consensus and implement new methods.

- Data and information management and access have to be considered in light of the revolution in information technology. Who will interpret and publish data and how will results be communicated to both the user audience and the general public? Should raw data be published to allow users to analyze and interpret them? How should research data be handled versus monitoring data? What distinctions should be made between communal (basic monitoring data, available immediately) and proprietary (individual researchers' data, maximum holding time 2 years) data?

- The Framework provides mechanisms and impetus for multidisciplinary research and "cross-pollination" among working in different disciplines and environmental media.

Research can also contribute to the Integrated Framework by improving the effectiveness of monitoring and interpretation of monitoring results. Focal points for research which can improve monitoring include the following:

formulation of testable hypotheses based on management questions for monitoring program design;

determining the key parameters to be measured and frequency of measurement;

development of new technologies for use in monitoring;

scale integration;

relating structural (e.g. population abundance, biomass, species composition) and functional (production, biogeochemical rates, etc.) characteristics of ecosystems;

optimal design of monitoring;

methods for dealing with extreme or infrequent events; and

manipulative experiments to understand the responses of populations, communities or ecosystems;

statistical and other tools for trend detection.

A challenging requirement for research integration into the Framework relates to the need to consider social and economic processes in environmental assessments posing the following requirements:

development of more effective communications between natural and social scientists;

data management systems to serve both natural and social scientists;

more research on the economic, social and cultural aspects of the Reference Issues;

research on the design of environmental assessments which incorporate socioeconomics with natural sciences;

methods to develop valuation methods to estimate costs of impairing environmental systems; and

workshops to introduce social scientists to the Framework process.

The Framework calls for the increased use of remote sensing and in-situ observing systems in regional monitoring. This presents opportunities for advancing research as well:

joint sponsorship of shared capabilities and products (for example, federal agencies have benefited by sharing in the acquisition and use of remote sensing imagery);

greater involvement of the international community;

calibration, ground truth, and sensor development;

development of spatially explicit models based on remote sensing products;

spatial and temporal scaling;

research on data and information management required to handle remote sensing data on real time basis;

introduction of other remote sensing tools, including ground-penetrating radar and seismic

and conductivity methods, etc.; and

increased access to supercomputer facilities.

The Framework includes the operation of Index Sites, where more intense, long-term monitoring and research activities will be focused. Considerations for the selection and support of these Index Sites include the following:

fully open competition based on proposals as has been done for LMER and LTER sites may not provide appropriate distribution of sites geographically or by habitat;

sites representative of range of different land uses, e.g. pristine, agricultural, urban/suburban etc., should be included;

long-term support for sites should be assured and this may require multi-agency and multi-institutional participation;

site visitation committees are needed to periodically review and evaluate individual site programs;

a management structure for the site network to provide leadership, services, information management, and quality assurance;

site selection criteria should include stratification (ecosystem type, use, ecoregions, etc.), goals and site characteristics (representativeness, external influences, etc.);

some criteria for selecting coastal Index Sites are different that those for terrestrial sites; and

sites should contribute to regional assessment of environmental change.

Information and Data Management

This breakout group believed strongly that the objectives of the Mid-Atlantic Pilot needed to be defined prior to the design of the appropriate supporting data management activities. Specifically, data management should provide a service to the Pilot's issue-oriented program(s) and be an integral part of each issue's planning from the beginning.

As a general principle, it was recommended that the objective be to provide the best possible integrated products, including both remote and in situ observations as appropriate, even though this might mean that the data on which these products were based might not be openly available due to their restricted or proprietary nature.

A possible immediate activity could be an inventory of environmental data and information currently available for the Mid-Atlantic region. Several breakout groups deliberating on Opportunities and Needs recommended such stock-taking for several reasons, including helping decide, after extensive assessments, whether any modifications to the existing observing system were needed, providing the best possible basis for follow-on specific issue assessments and

helping with the development of regional environmental baselines.

The actions recommended for such a possible initial Pilot activity were the development and dissemination via the Internet, CDs, and paper copy of (1) a catalogue of existing regional environment related documents, including earlier assessments; and (2) an index of the existing regional environmental data, whether current or historical. For each data set, an attempt would be made to obtain its high level descriptors listed below. (The list is limited to 10 descriptors so as to not discourage possible contributors.)

1. Content
2. Intended use
3. Location/extent and collection date
4. Spatial and temporal scale
5. Quality estimate
6. Format
7. Source of origin
8. Point of contact
9. Availability
10. Media of availability

Also, there was consensus that the Pilot should have specific assessment issues (e.g. the Reference Issues) identified to focus its efforts. While the objective of the Integrated Monitoring Framework requires functional unity and comparability of the databases, it is likely that the various constituent programs of the Mid Atlantic Pilot will have somewhat different data formats and requirements. Data managers from those constituent programs should be included in a coordination group to provide focused data management activities that would include:

1. Data and information acquisition
2. Establishment of a GIS interface
3. Metadata documentation
4. Data assessment and product generation
5. Data distribution and user access
6. Results/products distribution

At the Workshop State and regional managers and monitoring program directors stressed that specific and important assessment products should be produced within the first two years of the Mid-Atlantic Pilot for it to find application and retain participation. Coupling this time constraint

with the limited resources available for the Pilot makes it doubly clear that at least the initial list of Pilot assessment issues needs to constrained.

It was recognized that the integrated assessment products in particular must be in forms, including hard copy, that can not only be used with confidence by a broad user community but be generally recognized as better than such products that now exist. Included in this broad user community that must be "sold" on the Pilot's importance are the general public, educators, and policy makers at all levels as well as researchers.

Finally, it was recommended that to be successful the data management program required for the Pilot be guided by a team with federal, state, regional, and NGO representation, with operational support provided from the federal agencies. The support team would be responsible for implementing the data management backbone for this Pilot.

Assessment and Information Transfer

This breakout group examined how can we best integrate information across scales to allow informed, scientifically rigorous management decisions for the Mid-Atlantic Region. What characteristics of the assessment process will ensure success?

The assessment process must involve science and management components, and all must understand the roles and linkages among questions, monitoring, assessments, and decisions and the adaptive nature (feedback loops) among these components of the process. The major obstacles to successful assessments include the following:

- Failure to recognize the need to integrate science with management, policy making and public involvement. Assessments must be question driven and policy or management relevant.
- Artificial boundaries between public and private institutions (federal, state and local agencies, universities, non-governmental organizations, land owners.) prevent efficient resolution of problems and issues.
- Lack of institutional commitment to long-term needs, frequently changing priorities, and failure to assign the best talent to the problem means that assessments are not successfully

Assessment

The term "assessment" was used to mean different things. Some Workshop participants used the term to mean an inventory and review of past or ongoing programs. Assessments in MAIA generally involve comparing a variety of data to determine the general health of the environment and what the problems are. However, as used in this section, assessment is an activity focused on the causes, predictions and solutions related to a specific problem. For example, Cowling (1992) defines assessment as "a process by which scientific and technological evidence is marshaled for the purposes of predicting the outcomes of alternative courses of action." He further writes that "assessment is focused on reporting an integrated view of current conditions and future projections, including causes and effects, control options, costs and benefits of controls, and sufficient analysis of future scenarios to identify potentially efficient and effective control approaches."

completed.

. Failure to recognize and fill the need for education at all levels in the assessment process.

A key ingredient of successful assessment is involvement—involvement of technical contributors, decisionmakers and stakeholders. In addition, some important lessons from other assessements include

The Chesapeake Bay Program continues to demonstrate that public awareness, high-level political commitment, and responsiveness to technical information are key ingredients.

The National Acid Precipitation Assessment Program demonstrates the need to tightly couple monitoring and assessment (NAPAP, 1991).

The International Joint Commission of the Great Lakes demonstrates the value of hypothesis-driven assessments.

Waquoit Bay, Cape Cod, is an example of the ability of management to adapt to changing assessment resulting from new research discoveries.

These and other "lessons" give rise to a number of guiding principles for environmental assessment: (a) a simple statement of the problem is required; (b) assessment is an iterative process which must contend with ignorance at all levels of policy, management and science and inherent uncertainty; (c) all assessments are interim assessments; (d) science, policy, management and the public should be encouraged to be involved in assessment process; (e) all levels of assessment activity go on simultaneously; and (f) the assessment process must be hypothesis-driven toward the goal of prognosis.

Based on these considerations, the following recommendations are offered for implementation of the Integrated Monitoring Pilot in the Mid-Atlantic region:

. Give assessment primacy. Experience has shown that without the clear designation that monitoring and research serve assessment to inform decisionmaking, data collection consumes time and resources, leaving assessment as a hurried, under-funded after thought. Without sound assessment, collecting more data makes no difference.

. Assessment must start immediately with clear motivation and commitment.

. Apportion financial support according to what it takes to get the job done, with assessment activities of modeling, analysis, interpretation and translation as an equal priority to monitoring and research.

. Integrated (multi-disciplinary, cross-media) teams are needed for integrated assessments.

. Social, cultural and economic effects must be explicitly addressed.

. Education of scientists, managers and the public is needed to understand the assessment in context.

. Uncertainties associated with prognosis must be evident.

Regional Pilot Implementation

Assessments Must Guide Monitoring: Implementation of an integrated monitoring program for the Mid-Atlantic region must be founded on clear goals and objectives, which require further refinement beyond this workshop. Assessments, in the sense of (a) more in-depth appraisal of the most important environmental and natural resource issues, (b) the information needed to support wise management, and (c) determining our ability to truly integrate existing regional programs, are of central importance. The Workshop produced a consensus that **a core assessment should be initiated immediately, prior to major structural reorganizations or commitments that are difficult to reverse**. This assessment should provide direction for the Regional Pilot and National Frameworks on an regular basis in support of their incremental implementation and should result in a comprehensive assessment in approximately two years which will provide long-term guidance.

A key need in these assessments and for underpinning the integration of various programs is in the area of scaling. It was the consensus of the Workshop that the Regional Pilot should address the entire region, but it is clear that some sub-regions, such as the Chesapeake Bay and its watershed and the Mid-Atlantic Highlands, are being and will be monitored much more intensively and at different time scales. Thus, developing the ability to extrapolate and interpolate information across space and time scales will be critical to the success of regional as well as national monitoring.

It is critical that the Mid-Atlantic Pilot and the National Framework implementation continue to address important policy, management and regulatory needs. Strong linkages between science and policy are essential for both policy and technical decisions regarding risk and ecosystem management and sustainable development. It is important to ensure that research programs are anticipatory to prevent, not just mitigate, environmental threats. The National Framework should define critical policy questions and issues relevant to environmental monitoring and research, such as the Reference Issues used to guide the deliberations of this Workshop. The scientific knowledge and corresponding research necessary to meet those policy challenges should then be identified and an interagency/state implementation plan be developed.

Additionally, there are regional issues and existing assessment programs which should serve as a strong foundation for regional monitoring in the Mid-Atlantic, such as the Mid-Atlantic Highlands Assessment (MAHA), the Mid-Atlantic Integrated Assessment (MAIA) being conducted by EPA Region III, the Chesapeake Bay Program, and management and monitoring activities related to ground level ozone (Ozone Transport Commission, CASTNet, AIRMoN, PAMS, etc.). These programs already address the issues of air quality, atmospheric sources, land use and cover, and water quality in a relatively comprehensive way and thereby provide an "inherent competitive advantage" for the region.

A key element of the National Framework is that intensive monitoring and research will be

carried out at a limited number of sites, called Index Sites. The selection of these Index Sites is bound to produce differences of opinion among agencies and regional interests. On one hand, there is a sense of urgency to select and begin monitoring at Index Sites so that we can begin to establish long-term, systematic observations and learn by doing. On the other hand, there is a reluctance to select Index Sites without careful assessment of the issues of concern and the criteria for site selection. A majority of participants in the Workshop felt strongly that certain assessments and surveys need to be completed prior to selection of Index Sites within the Mid-Atlantic Region. However, postponing the selection of Index Sites until the completion of a protracted assessment of several years would result in the failure to include a key element of the National Framework in the Regional Pilot. A reasonable middle ground would be to focus attention to the issue of Index Site selection in the early stages of the core assessment described above. This could then be accomplished over a period of months rather than years, but still involve informed decisions and multi-party consensus. The Regional Pilot thus offers the opportunity to test an early set of Index Site selection criteria before advancing to the national level.

Organizational Requirements : Implementation of the Mid-Atlantic Regional Pilot will require high-level commitment and participation among Federal and State agencies through an Executive Committee and steadfast attention to the execution by a Program Coordination and Implementation Committee. In addition, an Executive Secretary and support staff will be required. A number of technical working groups, which support the Program Coordination and Implementation Committee, must address specific issues such as information and data, integration of research and monitoring, assessment (including modeling and scaling considerations), and communications both within the federal and state agencies as well as with external groups. It is essential to the success of the program that the states and private stakeholders be involved at all levels of the program, from development of the National Framework to its regional implementation.

The **Executive Committee** should be comprised of Assistant Secretary-level representatives from the federal agencies and the Office of Science and Technology Policy and high-level state officials. It should be the policy decision-making body for the Regional Program and be responsible for budget formulation, i.e. making institutional and financial commitments.

The **Program Coordination and Implementation Committee** should be composed of both federal and state program managers (e.g. NAWQA Director, EMAP Director) and representatives of the regional environmental research community. This committee should be the science and technology body for the Regional Program and responsible for execution of the program within the budget formulated by the Executive Committee. This is the level where breaking down existing barriers to effective integration and tendencies to protect turf is of the utmost importance. The Program Coordination and Implementation Committee (PCIC) should meet frequently and report to the Executive Committee, which should meet infrequently to set direction and reaffirm commitments. Critical next steps for the PCIC include (a) setting goals; (b) developing performance evaluation criteria; and (c) developing a state and public involvement strategy.

An **Executive Secretary** (coordination lead) and support staff should be established to ensure that the decisions of the Executive Committee and PCIC are implemented. This office may be supported by interagency pooling of resources and by seconding staff. There should also be a designated communication lead whose goal is to get "buy-in" at all levels for the Mid-Atlantic Pilot and the National Framework. This includes both "inreach" (to federal and state agencies) as well as outreach activities. Deliberate planning for both coordination and communication is essential if the Regional Pilot and National Framework are to be successful.

The technical working groups should be comprised of scientific and technical staff from the federal and state agencies, academia and other partner organizations. The working groups are the heart of the program and provide the scientific and outreach underpinnings for the Regional Pilot.

In developing the organization and operations for Regional Monitoring Implementation it is important to look for lessons learned by similar activities, e.g. the Chesapeake Bay Program Office and Southern Appalachian Mountain Initiative (SAMI). By the same token, it is realized that organizational structure alone does not guarantee success. Rather, committed and talented leaders are the key ingredients. It is important to foster and support the emergence of such "champions" at both the science and policy levels to carry this initiative forward.

Resource Requirements: While a catch phrase of the day is "do more with less" and it is clearly the implicit expectation of the National Monitoring Framework that existing efforts could be modified and coordinated to yield significantly improved results, it should be recognized that resources will be required for implementation of the Mid-Atlantic Regional Pilot. First, there must be the will and flexibility to adapt existing programs—including reallocating resources as appropriate—to accomplish the goal of integrated monitoring. Secondly, the intense monitoring and research projected for index sites under the National Framework is not now taking place and will require resources to implement. Thirdly, several existing programs that would be important contributors to integrated environmental monitoring in the Mid-Atlantic have been recently scaled back or are slated for termination. These efforts need to be adapted and sustained if regional monitoring goals are to be met. Finally, strategic investments are required to fill critical gaps and provide the "glue" (e.g. for coordination, assessment and information management) needed for integration. While it may be realistic to expect that in the end significant efficiencies and resource savings may be accomplished through integrated environmental monitoring in the region, the practical reality is that it will take an additional investment of resources to catalyze the implementation of the integrated monitoring program.

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Appendix 1. Workshop Participants and the Breakout Groups in Which They Participated.

NAME	ORGANIZATION	GROUPS(S)
John Aber	Complex Systems Research Center	
Mary Beth Adams	U.S. Forest Service	Terrestrial, Research
Raymond Alden III	ODU-Applied Marine Research Lab	Coastal, Pilot
Tabor Allison	National Science Foundation	
J. Scott Angle	Univ. Maryland Agric. Experiment Station	Terrestrial, Pilot
Mary Barber	Ecological Society of America	Synthesis, Assessment
Roger Barlow	U.S. Geological Survey, Data Prod. & Integration	Synthesis, Information
Thomas Barnwell, Jr.	U.S. EPA/NERL	Synthesis, Research
Richard Batiuk	U.S. EPA/Chesapeake Bay	Coastal
Jim Benson	U.S. Department of Agriculture/NRCS	
Rosina Bierbaum	Office of Science and Technology Policy/ENV	
Rona Birnbaum	U.S. EPA/Office of Air and Radiation	Atmospheric, Pilot
Donald Boesch	Univ. Maryland/CEES	Pilot
Walter Boynton	Univ. Maryland--Chesapeake Biological Lab.	Coastal, Research
Owen Bricker	U.S. EPA/ORD	Aquatic, Research
Carolyn Brown	National Marine Fisheries Service/OREI	Coastal, Research
John Cairns, Jr.	Virginia Polytechnic Institute/State University	
Tony Clark	North Carolina State University	Coastal
Emery Cleaves	Maryland Geological Survey	Synthesis, Research
Jeff Cornwell	Univ. Maryland--Horn Point Environmental Lab.	Coastal, Coordination
Ellis Cowling	N.C. State Univ./School of Forest Resources	Atmospheric, Assessment
Michael Crosby	NOAA/NOS/ORCM	Coastal, Assessment
Ford Cross	NOAA/NMFS/Beaufort Lab/SEFSC	Coastal
Doug Curtis	National Park Service	Aquatic, Assessment
Thomas DeMoss	U.S. EPA Region 3	Synthesis
Robin Dennis	U.S. EPA/NOAA-ASMD	Atmospheric, Assessment
Donald Dreves	NOAA/CIA (ORD-EPG)/Global Env.	Synthesis, Information
Paul Dunn	U.S. Forest Service	
William Eichbaum	World Wildlife Fund	
Keith Eshleman	Univ. Maryland--Appalachian Environmental Lab	Aquatic, Research
Diana Esher	U.S. EPA Region 3	
L. Keith Evans	West Virginia DEP	Aquatic, Information
Peter Finkelstein	U.S. EPA/NOAA-ASMD	Atmospheric, Research
Miguel Flores	National Park Service	Atmospheric, Coordination

Timothy Foresman	Univ. Maryland--Baltimore County	Terrestrial, Pilot
Herb Freiberger	U.S. Geological Survey	Aquatic, Pilot
Bob Friedman	John Heinz Center	Synthesis
Philip Galvin	NY State Dept. of Env. Conservation	
Robert Gardner	Univ. Maryland--Appalachian Environmental Lab.	Terrestrial, Assessment
Jerry Garegnani	NASA Headquarters	
Elizabeth Gillelan	National Marine Fisheries Service	Synthesis, Assessment
Jeffery Goebel	USDA/NRCS	
James Gosz	Univ. New Mexico	Synthesis, Research
Frederick Grassle	Rutgers University	Synthesis, Research
Roger Griffis	NOAA	Synthesis, Assessment
M. Grant Gross	Chesapeake Research Consortium	Coastal, Pilot
Lawrence Harding	Univ. Maryland-- Horn Point Environmental Lab.	Coastal, Research
Tom Hart	U.S. Army Corps of Engineers	
Bruce Hayden	Univ. Virginia, Environ. Sciences	Coastal, Research
Karl Herman	National Biological Service/Univ. Tennessee	Terrestrial, Information
Bruce Hicks	NOAA	Atmospheric
Fred Holland	Marine Resources Research Institute	Coastal, Pilot
Jerrald Hollowell	Susquehanna River Basin Commission	Aquatic, Coordination
Robert Huggett	U.S. EPA/ORD	
Michael Huston	DOE-ORNL/Env. Sciences	Terrestrial, Research
Laura Jackson	U.S. EPA/ORD	Coordination
John W. Jones	U.S. Geological Survey	
Steve Jordan	Cooperative Oxford Laboratory	Coastal, Coordination
Chris Justice	Univ. Maryland--Geography	Synthesis, Coordination
Charles Kanetsky	U.S. EPA Region 3	Synthesis, Pilot
Paul Kapinos	U.S. Geological Survey	Atmospheric, Assessment
John Karish	National Park Service	Synthesis, Pilot
Jack Kaye	NASA	Atmospheric, Assessment
James Lynch	Penn State Univ./Forest Resources	Atmospheric, Research
Robert Magnien	Maryland Dept. Natural Resources	Synthesis, Coordination
Margaret Maizel	Nat. Center for Resource Innovations	Terrestrial, Information
Robert Mangold	U.S. Forest Service	Terrestrial, Pilot
Suzanne Marcy	U.S. EPA/NCEA	
David Mathis	U.S. Army Corps of Engineers	
Lisa Matthews	Office of Science and Technology Policy/ENV	Pilot
Les Meredith	U.S. Department of Agriculture/TFODM	Information
Jarvis Moyers	National Science Foundation	

Peter Murdoch	U.S. Geological Survey	Aquatic, Coordination
Curtis Olsen	Department of Energy/Health, Env. Research	Coastal, Research
Paul Orlando	NOAA/NOS	Coastal, Assessment
John F. Paul	U.S. EPA/ORD/NHEERL/AED	Synthesis, Pilot
Thomas Pheiffer	U.S. EPA/ORD	
Harry Pionke	Agricultural Research Service	Terrestrial, Pilot
Randy Pomponio	U.S. EPA Region 3	
Dana Porter	Univ. Maryland--Baltimore County, Geography	
Michael Principe	New York City Dept. Env. Prot.	Aquatic
Walter Rawls	Agricultural Research Service	Research
Jim Rawson	WV Dept. Natural Resources	Aquatic, Assessment
Adelaide Rhodes	NOAA Coastal Ocean Program	
Andrew Robertson	NOAA/NOS	Coastal, Pilot
Barbara Rosenbaum	U.S. EPA	Research
Michael Ruggiero	Office of Science and Technology Policy/ENV	Pilot
Marc Safley	USDA/NRCS	Synthesis, Information
Dan Salkovitz	VA Dept. of Env. Quality	Atmospheric, Coordination
Donald Scavia	NOAA	
Anne-Marie Schmoltner	National Science Foundation	Atmospheric
Kent Schreiber	National Biological Service/Leetown Science Center	Aquatic, Assessment
Denice Shaw	U.S. EPA/ORD	Synthesis, Coordination
David Shriner	Department of Energy	
John Silvasi	U.S. EPA/OAQPS	Atmospheric, Coordination
Michael Slimak	U.S. EPA/ORD	
Roland Steiner	Interstate Comm. Potomac River Basin	Pilot
John Stoddard	Dynamac Corp.	Synthesis, Assessment
Timothy Strickland	USDA/CSREES	Terrestrial, Pilot, Research
Timothy Stuart	Council on Environmental Qualtiy	
Nancy Tosta	Department of Interior/Geographic Data Comm.	
Bo Tumasz	U.S. EPA/ORD-EPG	
Robert Unnasch	The Nature Conservancy	Terrestrial, Coordination
Mark Walbridge	George Mason University/Biology	Terrestrial, Research
Jeff Waldon	Virginia Tech./Fisheries-Wildlife	Synthesis, Information, Pilot
Janice Ward	U.S. Geological Survey	Aquatic
Rick Webb	Univ. of VA/Env. Sciences	Aquatic, Information
Stephen Weisberg	Versar, Inc.	Coastal, Coordination
Jeffrey West	GENCO/GPU	Atmospheric, Coordination
R. Kelman Wieder	Villanova Univ./Biology	Aquatic, Research

BruceWiersma	Univ. of Maine	Terrestrial, Coordination
Helen Wiggins	Univ. Maryland--Baltimore County	Terrestrial, Information
Steven Wofsy	Harvard University	Atmospheric, Assessment
Garth Youngberg	Wallace Inst. for Alternative Agriculture	Terrestrial

Appendix 2. Chairs and Rapporteurs for Topical Breakout Groups

Group	Chair(s)	Rapporteur
The Atmosphere	James Lynch	Bruce Hicks
Terrestrial Environments	Bruce Wiersma	Tim Strickland
Aquatic Environments	Keith Eshleman	Peter Murdoch
Coastal Environments	Ford Cross	Andrew Robertson
Regional Synthesis	J. Frederick Grassle	Roger Griffis
Integration and Coordination of Monitoring Programs	Robert Magnien Steve Jordan	Denice Shaw
Integration of Research and Monitoring	Bruce Hayden	Owen Bricker
Information and Data Management	Karl Herman	Les Meredith
Assessment and Information Transfer	Robert Gardner	Roger Griffis
Regional Pilot Implementation	John Karish	Lisa Matthews

Appendix 3. Explanation of Abbreviations and Acronyms Used.

AIRMoN	Atmospheric Integrated Research Monitoring Network
AVHRR	AdvancedVery High Resolution Radiometry
CASTNet	Clean Air Status and Trends Network
CBOS	Chesapeake Bay Observing System
CBP	Chesapeake Bay Program
C-CAP	Coastal Change Analysis Program
COP	Coastal Ocean Program
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
FHM	Forest Health Monitoring Program
FIA	Forest Inventory and Analysis
GAP	Gap Analysis Program
GIS	Geographic Information System
GOOS	Global Ocean Observing System
IMPROVE	Interagency Monitoring of Protected Visual Environments
ITFM	Integrated Task Force for Monitoring of Water Quality
LMER	Land Margin Ecosystem Research
LTER	Long Term Ecological Research
MAB	Man and the Biosphere
MAHA	Mid-Atlantic Highlands Assessment
MAIA	Mid-Atlantic Integrated Assessment
MARMAP	Marine Resource Monitoring, Assessment, and Prediction
MRLC	Multi-Resource Land Characterization
MSS	Multi-Spectral Scanner
NADP	National Atmospheric Deposition Program
NAMS	National Air Monitoring System
NAPAP	National Acid Precipitation Assessment Program

NARSTO	North American Research Strategy for Tropospheric Ozone
NASA	National Aeronautics and Space Administration
NASQUAN	National Surface Water Quality Network
NAWQA	National Water Quality Assessment
NBS	National Biological Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRC	National Research Council
NS&T	National Status and Trends
NSTC	National Science and Technology Council
OSTP	Office of Science and Technology Policy
PAMS	Photochemical Air Monitoring System
PANDA	Program on Atmospheric Nutrient Deposition Assessment
PCIC	Program Coordination and Implementation Committee
SAMI	Southern Appalachian Mountain Initiative
SAMS	State and Local Air Monitoring System
SEAMAP	Southeast Monitoring and Assessment Program
SERC	Smithsonian Environmental Research Center
SOS	Southern Oxidants Study
SWAS	Shenandoah Watershed Study
TM	Thematic Mapper (associated with Landsat imagery)
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VTSSS	Virginia Trout Stream Sensitivity Study

Appendix 4. Description of Major Federal and other Environmental Monitoring and Research Networks and Programs with Relevance to the Mid-Atlantic Region.

MAJOR FEDERAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

Inventories and Remote Sensing Programs

Program Name (Acronym)	C-CAP	GAP	MRLC	NWI
Program Name (Full)	Coastal Change Anal Pr.	Gap Analysis Program	Multi Resol.Land Charact.	Natl Wetlands Inventory
Agency	NOAA	NBS	EPA/USGS/NOAA/NBS	DOI,Fish & Wildlife Serv.
Year Initiated	1990	1988,1994 funded	1992	1978
Measures	Land cover change	4 basic data layers	Electromag,radia,lnd cov	Determine extent & type...
Collection Source				
Point	-	x	-	x
Source	-	x	x	x
Transect	-	x	-	x
Other area	Satellt.imag & aerial ph.	Satellite imagery	TM image	Color infrared photography
Locations for Data Collection	In 16 states,coastal US	40 states involved	540 scenes all over U.S.	Done 85%/US land cover
Temporal Interval	Every 1-5 years	Optimal-every 5 years	1992-1995(every 10 yrs)	10 year intervals
Sampling Design				
Random	-	-	-	x
Selected	-	-	-	-
Synoptic	x	x	x	-
Data Available	Yes	Some	Yes	Yes
Accessible	CD ROMS sold at cost	In 10 states now-Internet	USGS EROS data center	Maps, internet
Extent for Reporting	By estuar. drainage area	US (starting 1 in Hawaii)	Continental U.S.	50 states,4 sq.mi.plots
Partners				
International	-	-	-	-
Agency	Numerous Federal	EPA, Dept.of Defense	EMAP,GAP,NAWQA,CCAP	Federal Resource Agen
State	State cooperators	State agencies	-	All 50 states
Local	Local cooperators	Local agencies	-	Private sector, local govt.
Authorities/Reason for Running Prg.	Study cov.change & eff.	Fish & Wild. Coord. A.	Land cover data required	Emerg Wetland Resour.A
Users of Data per Year	Hundreds	800 a month on internet	200	1.6 million paper NWI maps
Program Meets Metadata Standards	Yes	Yes	Partly	Yes
Expansion of Prog (Needed/Not)	Needed	Needed	Needed	Needed
Contact Person	Don Field	Michael Jennings	Denice Shaw	Dr. Bill O. Wilen
Phone #	803-974-6233	208-885-3565	919-541-2698	703-358-2161

MAJOR FEDERAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

National and Regional Surveys - Part 1

Program Name (Acronym)	BBS	CASTNET	EMAP	FHM
Program Name (Full)	Breeding Bird Survey	Clean Air S&T Network	Envir.Mon & Assess Pro	Forest Health Monitoring
Agency	NBS	EPA mainly,multi-agency	EPA	Multi-ag.,EPA & USDA
Year Initiated	1966	1988-lst data 1991-frmd	1988	1990
Measures	Anim species, weather	Sulfate,nitrate,cations	multi-resource eco-ind.	Collect data trees,plants
Collection Source				
Point	-	x	-	-
Source	-	-	x	x
Transect	-	-	-	-
Other area	Route	-	-	Radiation,remote sensing
Locations for Data Collection	3000 routes-50 points	55 sites in U.S.	12,600 sites in U.S.	4,000 forested plots
Temporal Interval	Yearly	Weekly	Annual	
Sampling Design				
Random	x	-	x	
Selected	-	x	-	Annual(June 15-Sept 15)
Synoptic	-	-	-	-
Data Available	Yes	Yes	Yes	x
Accessible	Internet,CD ROM, disk	Data Clearinghouse	Internet,CD ROM	Developing it on Internet
Extent for Reporting	24.5 mile routes	1-10 square km	640 square km	1 hect.plot & 4 subplots
Partners				
International	Mexico,Canada	Canadian government	Soviet Union, Can, Czech	-
Agency	Wildlife agencies	Federal agencies	Federal agencies	Bureau Land Mgt.,NRC's
State	Priv. org. state govt.	State agencies	State universities	State forestry
Local	Universities	Universities	-	-
Authorities/Reason for Running Program	N.Am. migratory bird act	Clean Air A, Cana AQA	Clean Air Act,NEPA	88 For. Ec & Atm Re Act
Users of Data per Year	Thousands	150	Thousands	Hundreds
Program Meets Metadata Standards	Not Yet	No	Yes	Working on it
Expansion of Program (Needed/Not Needed)	Needed	Needed	Needed	Needed
Contact Person	Bruce Peterjohn	Jim Vickery	Laura Jackson	Robert Loomis
Phone #	301-497-5841	919-541-2184	919-541-3088	919-549-4020

MAJOR FEDERAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

National and Regional Surveys - Part 2

Program Name (Acronym)	FIA	NADP/NTN	NAMS/SLAMS	NASQAN
Program Name (Full)	Forest Inventory Analysis	Natl Atmos Dep Pr/Trends	Nat Air Mon sta/st. & loc	Nat Stream Qu Acct Net
Agency	USDA Forest Service	USGS	EPA,State &loc agen ow	USGS
Year Initiated	1930	1978	1979	1973
Measures	Forest attribts,type,size	Precip.chem.cation,anions	Criteria pollutnts,metallic	Major ions,nutr.,DOC
Collection Source				
Point	x	x	x	x
Source	x	-	-	-
Transect	-	-	-	-
Other area	-	-	-	-
Locations for Data Collection	1 plot per 1500-7500 ac.	192 sites in U.S., 1 in Can.	5000 samplrs,3150 sites	1996 35 sites
Temporal Interval	7-12 years	Weekly	Hourly,Pb&PM10 variable	Pres to future,18 t. Yrly.
Sampling Design				
Random	x	-	-	-
Selected	-	-	x	x
Synoptic	-	x	-	-
Data Available	Yes	Yes	Yes	Yes
Accessible	Disc,see attachment	Pub.yrly in data summary	EPA reg offices,AIRS	NWIS
Extent for Reporting	1/6 to 2.5 acres	Points create isopleths	Primarily urban,some rura	Trend anal. at rivr flx pt.
Partners				
International	-	-	-	Mexico, Rio Grande...
Agency	Federal agencies	EPA,D.of Agr. NPS,NOAA	EPA Regions	USGS
State	State resource agencies	State govt.,wildlife service	State agencies	-
Local	Citz.,envir grps,fores.ind	Private utilities,universities	Local agencies,contrctrs	-
Authorities/Reason for Running Program	Organic Act 1897,PL93	Clean Air Act of 1990	40CFR58	Part of Basic Water Data
Users of Data per Year	Thousands	Hundreds	450	Thousands
Program Meets Metadata Standards	Working on it	Yes	No	Will meet ITFM standards
Expansion of Program (Needed/Not Needed)	Needed	Not needed	Not needed	Needed
Contact Person	Brad Smith	Paul Kapinos	David Lutz	Rick Hooper
Phone #	202-205-0841	703-648=6876	919-541-5476	770-903-9146

MAJOR FEDERAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

National and Regional Surveys - Part 3

Program Name (Acronym)		NRI	NS & T	
Program Name (Full)	Nat Stream Gaging Net	Natl Resources Inventory	National Status & Trends	NMFS Stock Assessment
Agency	USGS	USDA-NRCS	NOAA	NOAA/NMFS
Year Initiated	1888	1956-CNI,1977-now TRI	1984	1871
Measures	H20 disch,levels,temp.	Status & trends of soil H20	Chem.contam.in mussels...	Fisheries catch and effort...
Collection Source				
Point	x	x	x	x
Source	-	x	-	x
Transect	-	x	-	x
Other area	-	-	-	-
Locations for Data Collection	7200 stations	800,000 samp sites US/Car	260 sites in U.S.	200 naut mile zone off coast
Temporal Interval	Continuous	Every 5 years	Annual	Annual
Sampling Design				
Random	-	x	-	-
Selected	-	-	x	x
Synoptic	x	-	-	-
Data Available	Yes	Yes	Yes	Yes
Accessible	WATSTORE,NAWDEX	CD ROM,Internet,offices	Internet, diskette	Reports, Internet, CD, disk
Extent for Reporting	Puerto Rico,Guam,U.S.	Any geographic unit	20 km between sites	Multiple scales
Partners				
International	U.S.Territories	-	United Nations	Univ, Commissions, Agencies
Agency	Fed.Ener.Reg licensees	Agencies,Nat.Resour grps	EPA...	13 federal
State	State agencies	Forest Serv.,Iowa State U.	State governments	66 State & Territorial
Local	Local agencies	Local convervation districts	Local municipalities	-
Authorities/Reason for Running Program	Organic Act.Sundry Civil	Rural Devel Act.Security A	Marine Prot.,R & S Act	4 federal statutes
Users of Data per Year	No idea	No idea	1,000	1,000s
Program Meets Metadata Standards	Don't know	Not yet	Yes	Yes
Expansion of Program (Needed/Not Needed)	Needed	Needed	Needed	Needed
Contact Person	Ernest F. Hubbard	Jeff Goebel	Tom O'Connor	Carolyn Brown
Phone #	703-648-5312	202-720-9032	301-713-3028 ext 151	301-713-2363

MAJOR FEDERAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

National and Regional Surveys - Part 4

Program Name (Acronym)	PAMS	RAWS or AWS	SNOTEL	
Program Na	Photoch.Asses.Mon Stat.	Remote Auto Weather	Snowpack Telemetry	
Agency	EPA,State& loc agen ow	Multi-Agency	NRCS	
Year Initiated	1994	Late 70's,early 80's	1978	
Measures	Bckgrnd conc,hydrocarb	Fire danger, wind, air...	Snow H20 cont.,precip...	
Collection Source				
Point	x	x	x	
Source	-	-	-	
Transect	-	-	-	
Other area	-	-	-	
Locations for Data Collection	57 sites in US,grow rapid	500 weather stations	560 sites/West of 100mer.	
Temporal Interval	Continuous	Generally hourly	Daily-hourly	
Sampling Design				
Random	-	-	-	
Selected	x	x	x	
Synoptic	-	-	-	
Data Available	Yes	Yes	Yes	
Accessible	EPA reg.offices,AIRS	West Region Climate Ctr.	Working towards internet	
Extent for Reporting	4 types of monitors	-	100 square miles	
Partners				
International	-	-	Canada,Mexico	
Agency	EPA Regional Offices	USDA,USDI/BLM,NPS,BIA	BOR, COE, NWS	
State	State agencies	Fire Protection Agencies	Water Resour, state eng.	
Local	Local agency,Contractors	Fire Protection Agencies	Municipalities, tribes	
Authorities/Reason for Running Program	Clean Air A.Amen-1990	To protect public lands	PL46, Mem. 870, USDA	
Users of Data per Year	450	2000	3000	
Program Meets Metadata Standards	No-not FGDC standards	Yes	No	
Expansion of Program (Needed/Not Needed)	Needed	Needed	Needed	
Contact Person	Nash Gerald	Kolleen Shelley	Garry Schaefer	
Phone #	919-541-5652	208-476-8362	503-541-3068	

MAJOR FEDERAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

Intensive Monitoring & Research Sites - Part I

Program Name (Acronym)		ARS Water Database	Forest Serv Experimental	LMER
Program Name (Full)	Acid Rain Watersheds	Agricul Research Service	Forest & Rangeland Sites	Land Margin Eco Res.
Agency	USGS	USDA	USDA	NSF
Year Initiated	1982	1937	1909	1988
Measures	Ca,Mg.ph,K,SO4,NO3	Precip,stream flow,air temp	Hydrologic,wildlife,soil	Changes in coastal zone
Collection Source				
Point	x	x	x	x
Source	-	-	x	x
Transect	-	-	x	x
Other area	-	-	Satellite imagery, remote	Watershed
Locations for Data Collection	15 sites U.S.3 still oper.	333 watershed areas/US	83 experimental forests	4 sites
Temporal Interval	Weekly-monthly	Every minute	Varies-some continuous	Variable-Weekly to qurtlly
Sampling Design				
Random	-	-	x	-
Selected	x	x	x	x
Synoptic	-	-	x	-
Data Available	Yes	Yes	Yes	Yes
Accessible	USGS Database	REPHLEX II, Internet	Profess,literature,records	From individual sites
Extent for Reporting	10 square km or less	.2 hect to 12,400 sq km	Puerto Rico, US(Hawaii)	Coastal U.S.
Partners				
International	-	-	Puerto Rico	-
Agency	National Park Service	NRCS, Hydrology Lab	EPA,NBS,USGS,NOAA	NOAA, EPA, USGS
State	MD Dept.Natural Res.	State cooperative station	State agencies	State agencies
Local	State agencies	Universities	Univ.,priv.ind &landownr	Agen.,conserv.assoc.
Authorities/Reason for Running Program	Nat. Acid Rain Program	Reason for research	Renewable Resource A	Pred.coast resp to chang
Users of Data per Year	-	100	No idea	Unknown
Program Meets Metadata Standards	Yes	Yes	No	Yes
Expansion of Program (Needed/Not Needed)	Needed	Needed	Needed	Needed
Contact Person	Owen Bricker	Jane Thurman	Dick Cline	J.E.Hobbie
Phone #	202-260-5793	301-504-9411	-1527	508-548-3705 ext 7470

MAJOR FEDERAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS				
Intensive Monitoring & Research Sites - Part 2				
Program Name (Acronym)	LTER	MAB		NOAA COP
Program Name (Full)	L.Term Eco Mon & Resear	Man & Biosphere Prog.	Natl Park Eco Mon Prog	Coastal Ocean Program
Agency	NSF	Voluntary interagen prog	DOI/Natl Park Service	NOAA
Year Initiated	1980	1976	1991	1990
Measures	Around 5 core areas	List of measures on disc	H20 quality,veg.,birds	3 major program areas
Collection Source				
Point	-	x	x	x
Source	x	x	x	x
Transect	x	x	x	x
Other area	Grid system & satellite im.	International Network	Remote sensing	Satellite imagery,remote sen
Locations for Data Collection	18 sites in US, Puerto,Ana	47 US, 100 W.Hem, 324	5 funded prog, 11 not yt	9 sites
Temporal Interval	Hourly-annually	Variable	Varies from park to park	Minutes-yearly
Sampling Design				
Random	x	x	x	x
Selected	x	x	x	x
Synoptic	x	x	x	x
Data Available	Yes	Yes	Some	Yes
Accessible	Contact sites, Internet	Internet,homepage,UCD	Hard copy & floppy disc	Storets, thru prog man,univ
Extent for Reporting	Varies/plots 1 sq m-.10 hect	World-wide-114 nations	Ecosystem being rep.	Very narrow - infinite
Partners				
International	Yes	Yes	-	-
Agency	USDA-ARS,Nat.Conserv	EPA,NASA,NBS,AID...	Nat.Con.,NBS,EPA,FWS	EPA,USDA,D.of Int,USACOE
State	Forest Service	-	Universities	State agencies,universities
Local	-	-	Volunteer groups	Private industries
Authorities/Reason for Running Program	1.keep fund.base 2...	Voluntary Program	NPS Organic Act 1916	Part of NOAA's responsib
Users of Data per Year	a lot	about 1 million	-	No idea
Program Meets Metadata Standards	Developing	Yes	Working on it	Yes
Expansion of Program (Needed/Not Needed)	Needed	Needed	Needed (250 parks)	Needed
Contact Person	Scott Collins	Roger Soles	Gary Williams	Larry Pugh
Phone #	703-306-1483	202-776-8318	970-225-3539	301-713-3338

MAJOR FEDERAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

Intensive Monitoring & Research Sites - Part 3

Program Name (Acronym)		NOAA NEERS	USGS Benchmark	USGS Coop Program
Program Name (Full)	Natl Marine Sanctuary Pr	Natl Estuar Res Reserv Syst	Benchmark Network	Bisc.Brk.Wtrshd,Bnchmrk
Agency	NOAA	NOAA	USGS	USGS
Year Initiated	1972	1972	1965	1983
Measures	Ident desig mgmt areas	Water qual, temp, salinity	Stream disch.,major ions...	Soils,water quality,Al,Si
Collection Source				
Point	x	x	x	x
Source	x	-	-	x
Transect	x	-	x	x
Other area	-	-	-	-
Locations for Data Collection	14 sites in US (& territories)	21 sites, 21 data loggers	50 sites (Decrease in 96)	l watershed/tons stations
Temporal Interval	monthly-annual	Every half hour	Quarterly	15 minutes-monthly
Sampling Design				
Random	-	-	x	-
Selected	x	x	x	x
Synoptic	-	-		x
Data Available	Yes	Yes	Yes	Yes
Accessible	Thru site managers	Thru sites & on internet	District office sites,Kathy	WATSTOR,pmurdoch@
Extent for Reporting	US territorial waters	NERRS	Total export of watershed	Watershed scale-66 sq mi
Partners				
International	US territories	Mexico	-	-
Agency	DOI, NPS, Navy	EPA, DOI, DOC	Natl Park Service, Forest	EPA
State	State governments	State agencies	-	Univ. Of N.H., Syracuse U.
Local	Private industry, volunteers	Local agen, landowners	-	NYC Dept of Envir Protect
Authorities/Reason for Running Program	Marine Prot Resource & Sanc	Coastal Zone Mgmt Act	Organic Act	Research & Monitoring
Users of Data per Year	Don't know	.5 mill-prog info/100's-tech	30	Dozens
Program Meets Metadata Standards	Eventually	Yes	No	Need to review
Expansion of Program (Needed/Not Needed)	Needed	Needed	Needed	Needed
Contact Person	Jim Lawless	Randall Schneider	Kathy Fitzgerald	Pete Murdoch
Phone #	301-713-3155 x194	301-713-3132 x126	703-648-6902	518-285-5663

MAJOR FEDERAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

Intensive Monitoring & Research Sites - Part 4

Program Name (Acronym)	USGS NAWQA	USGS WEBB		
Program Name (Full)	Natl Water-Quality Asses	Water,energy,biog.budg		
Agency	USGS	USGS		
Year Initiated	1986 pilot,1991-full prog.	1991		
Measures	Assess qual, H20(stream)	Water & biogeoch		
Collection Source				
Point	x	x		
Source	x	x		
Transect	x	x		
Other area	-	Satellite imagery		
Locations for Data Collection	60 units, 2/3 nations H20	5 sites		
Temporal Interval	3 years of intens, 7 low	Minutes-daily		
Sampling Design				
Random	-	x		
Selected	x	x		
Synoptic	x	x		
Data Available	Yes	Yes		
Accessible	Distributed info system	Database, Home page		
Extent for Reporting	Study unit is 52,029 sq km	100's of square km		
Partners				
International	Mexico, Canada	Puerto Rico		
Agency	EPA	Army Corps of Eng,NPS		
State	State water agencies	Universities		
Local	Local water agencies	Municipalities, tribes		
Authorities/Reason for Running Program	Charged by Congress	Global Change Program		
Users of Data per Year	40,000	100		
Program Meets Metadata Standards	Yes	Don't know		
Expansion of Program (Needed/Not Needed)	Not needed	Needed		
Contact Person	Tim Miller	George Leavesley		
Phone #	703-648-6868	303-236-5026		

MAJOR REGIONAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

Mid-Atlantic Region Monitoring Programs - Part 2

Program Name (Acronym)	CBP Water Quality	VAGAP	CBP	SWAS
Program Name (Full)	Chesapeake Bay Program	VA Gap Analysis Project	Chesapeake Bay Progrm	Shenandoah Watershed Study
Agency	EPA	D. Of Fish & WildlifeSc.-VA Tech	EPA-Region III, lead	U. Of VA,National Park Svc.
Year Initiated	19 4	1994	1983	1979
Measures	physical, chemical	Land Cover/Wildlife Habitat	human impact on Bay	Acid-base chem.of strms & precip.
Collection Source		Landsat TM & anc. data		
Point	x	x	x	17 routine sampling sites, syn. Surveys
Source		x	x	
Transect		x		fish habitat surveys
Other area			x	
Locations for Data Collection	50 stations Chesapeake Bay	statewide	6 States in Ches.Basin	designated stream sampling sites
Temporal Interval	Monthly, twice monthly	single point/91-93 imagery		weekly and quarterly
Sampling Design				routine program, hierarchal design
Random				
Selected	x	selected		minimally disturbed upland watersheds
Synoptic				multiple synoptic surveys
Data Available	Yes	at present, clustered imagery	Yes	reported annually to sponsoring
Accessible	Internet	yes		
Extent for Reporting	Station	by scene,county,hydro.unit		Shenandoah National Park, VA
Partners		NBS,VA Dept of Game	over 40r	.
International				
Agency	Federal Agencies	USEPA,USFS,USFWS & Others	Federal, Universities	National Park Service, US EPA
State	State Agencies		x	University of Virginia
Local	Universities		x	
Authorities/Reason for Prog	NEPA/CWA	contract thru NBS	restore living resources	Watershed Ecosy. Monitoring & Res.
Users of Data per Year	thousands	n/a	Contract EPA	
Program Meets Metadata Stand.	Not Yet	yes	starting implementation	
Expansion of Prog(Needed/Not)	Not	needed		needed
Contact Person	Richard Batiuk	Jeff Waldon	Bill Matuszeski	Rick Webb
Phone #	410-267-5731	540-231-7348	410-267-5700	804-924-7817

MAJOR REGIONAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

Mid-Atlantic Region Monitoring Programs - Part 3

Program Name (Acronym)	VTSS			
Program Name (Full)	Va. Trout Stream Sensitivity Study	Otter Cr./Dolly Sods Water Qu.Surv.	Estuary Tributaries	
Agency	U.of V.,VA Dept of Game & Inl.Fisheries	Univ. Of Virginia, Forest Service	Del.Riv.Basin Comm.	
Year Initiated	1987	1994	1980	
Measures	Acid-base chemistry of streams	Acid-base chemistry of streams	Ambient Water Quality	
Collection Source			PA tribs & head of tide	
Point	reg. synpotic survey, 60 routine samp.sites	Spring '94 syn. survey: 125 sites	x	
Source				
Transect				
Other area				
Locations for Data Collection	designated stream sampling sites	designated stream sampling sites	10 PA tribs, 1 river	
Temporal Interval	stream water: quarterly	one time survey	1/month	
Sampling Design	routine program: hierarchal design	systematic spatially intensive	Major tributaries	
Random			Dates	
Selected	minimally disturbed upland watersheds	Class I wilderness area		
Synoptic	single synoptic survey	single synoptic survey		
Data Available	reported annually to sponsoring agency	reported to sponsoring agency	Yes	
Accessible			STORET & Hardcopy	
Extent for Reporting	22 western Virginia counties	Monongahela Nat. For. Class I areas	Delaware Estuary	
Partners	Va. Council of Trout Unlimited			
International				
Agency		USDA Forest Service		
State	Va.Dept of Game & Inl.Fish, U. Of V.	University of Virginia	2 states -coll. & analysis	
Local				
Authorities/Reason for Prog	Monitoring change in acid-base status	Coll. Of Class I area baseline data	Status,Trend,Modeling	
Users of Data per Year			Scores	
Program Meets Metadata Stand.			Yes	
Expansion of Prog(Needed/Not)	Needed	Needed	Needed	
Contact Person	Rick Webb	Rick Webb	Paul J. Scolly	
Phone #	804-924-7817	804-924-7817	609-883-9500	

MAJOR REGIONAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

Mid-Atlantic Region Monitoring Programs - Part 4

Program Name (Acronym)	VCR LTER	ARS Water Database	CBSAC-WDS	ODAS
Program Name (Full)	VA Coast Res. Long-Term Ecol.Resrch	Agricultural Research	Ches.Bay Stock Asses.Com	Ocean Data Acquisition
Agency	NSF	USDA	NOAA	NOAA
Year Initiated	VCR came on line in 1987	1957	1989	1989
Measures	Data on 5 core areas + them.studies data	Precip,StreamFlow,Air Temp	C.Bay Blue crab dynamics	surface chlorophyll
Collection Source				
Point	x	x		
Source	x			
Transect	x			x
Other area	Grid,Satellite,Aircraft,GPS		random dredge sample	Chesapeake Bay
Locations for Data Collection	VA Barrier Islands,Lagoons,Marshes	17 Watershed areas/US	Baywide(1,000-1,400 sites)	45 transects
Temporal Interval	Hrly to Annual depending on measurement	Every minute	Annual	weekly
Sampling Design				
Random	x		x stratified	
Selected	x	x		x
Synoptic	x			x
Data Available	Yes	Yes	Yes	Yes
Accessible	Published on Internet (Prog.Homepage)	REPlLEX II, Internet	NCBO Tables - Internet Acc.	Internet
Extent for Reporting	Varies 1sq.meter to 100s hect	3 ha - 1237ha	Chesapeake Bay	l km grid
Partners				
International	Hungary ILTER			
Agency	US Fish and Wildlife	NRCS, Hydrology Lab		Federal Agencies
State	Sea Grant (VMSC)	State Cooperative Sta	MD & VA,Univ of MD,VIMS	
Local	Northhampton County	Universities		Universities
Authorities/Reason for Prog	Study long change in ecosyst.(NSF grant)	Reason for research	Fish & Wildlife Act	NEPA/CWA
Users of Data per Year	84,898 in 1995	10	Unknown	100
Program Meets Metadata Stand.	LTER Metadata Stand.(partially in place)	Yes	don't know	not yet
Expansion of Prog(Needed/Not)	Risser Study:LTER sites need 3x funds	Needed	not needed	not
Contact Person	Dr. Bruce P. Hayden	Jane L. Thurman	Anne Lange	Bess Gillelan
Phone #	804-924-0545	301-504-9411	410-267-5660	410-267-5660

MAJOR REGIONAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

Mid-Atlantic Region Monitoring Programs - Part 5

Program Name (Acronym)		NARSTO - NE	NAMS/SLAMS		
Program Name (Full)	Assoc. Soils,Hydr & Veg.		Nat. Air Monitoring	Ambient	State Stream Gauging Net
Agency	Lower Del. Peninsula	Public / Private	VA,DEQ, Fairfax, VA	DEQ	DEQ
Year Initiated	1993	1995		1969	1925
Measures	Hydrol.,Soil Morph,Veg.	Met, NO, VOC, Ozone	Criteria Pollutants		
Collection Source					Wells, Streams
Point		x	x	x	x
Source		x			
Transect	x	x			
Other area		x			
Locations for Data Collection	Worcester Co., MD	Northeast U.S.		1,100 Sies	82 - 700 Wells
Temporal Interval	biweekly (Hydrology)	Ozone Season		Quarterly / Monthly	Continuous, Quarterly
Sampling Design					
Random				x	
Selected	x	x	x	x	
Synoptic		x		x	x
Data Available		yes	yes	yes	Yes
Accessible	x	Internet	AIRS	STORET,EPA,CBP,in	WATSTORE
Extent for Reporting				Statewide	Virginia, US
Partners					
International		Canada			
Agency				USGS, EPA	USGS
State	UMCP, MAES	Ozone Transport Region		DCR,VIMS,MRC	
Local			Fairfax Co.		
Authorities/Reason for Prog	Wetland ID	1990 eAAA		Clean Wtr Act,Ch Bay Act	Water Resource & Mgmt
Users of Data per Year			Hundreds	1,000 +	?
Program Meets Metadata Stand.		Under Development	No	partially	?
Expansion of Prog. (Needed/Not)		needed	Needed	Need to expand	Needed
Contact Person	Rokenhorst	Jeffrey L. West	Marshall Ervine	Ron	Paul Hegman
Phone #	301-405-1347	610-921-6448	804-290-7734	804-678-4472	804-698-4464

MAJOR REGIONAL ENVIRONMENTAL MONITORING AND RESEARCH NETWORKS & PROGRAMS

Mid-Atlantic Region Monitoring Programs - Part 6

Program Name (Acronym)					SOS-SON
Program Name (Full)	Experimental Forests	Nutrient Reduction	Interstate	Subbasin Intensive	So.Oxid.Stdy-
Agency	USDA Forest Service	SRBC	SRBC		EPA,TVA,SE States
Year Initiated	1931-64	1984	4/86	1980	1990
Measures		Nutrients & S.Sed	Biological & Chem	Biological & Chem	Ozone, Met.
Collection Source					
Point	x	x	x	x	
Source	x				
Transect	x	x			
Other area					
Locations for Data Collection	4 experimental forests	13 sites	91 sites	600	30 sites in 8 states
Temporal Interval	continuous to decades	6 - monthly	quarterly	10 years	Hourly
Sampling Design					
Random	x				
Selected	x	x	x		Rural Sites
Synoptic	x			x	
Data Available	yes	yes	yes	yes	Pub.Yearly,Data on Disks
Accessible		Hard copy, discs	Hard copy / disc	Hard copy / disc	Yes
Extent for Reporting		27,000 sq.mi. w/shed		5000 sq mi w/shed	Points create isopleths
Partners		Pennsylvania DEP	States / EPA	States / EPA	
International	NADP				
Agency	NSF, NBS	x	x	x	EPA Region IV
State	State Agencies	x	x	x	8 States
Local	Univ., private ind.				
Authorities/Reason for Prog		CBP	SRBC	SRBC	Ozone climatology
Users of Data per Year	thousands	States ?	100	100	100 per year
Program Meets Metadata Stand.	No		yes	yes	yes
Expansion of Prog(Needed/Not)	Needed	Needed	not	Needed	yes
Contact Person	M.B.Adams	Jerry Hollowell	Jerry Hollowell	Jerry Hollowell	Cassandra Wylie
Phone #	304-438-2000	717-238-0423	717-238-0423	717-238-0423	423-632-1645

MAJOR REGIONAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

Mid-Atlantic Region Monitoring Programs - Part 7

Program Name (Acronym)	SOS-SCION	SOS-SEMOR	SOS-Atlanta	SOS-Nashville, Mid.TN
Program Name (Full)	So.Oxid.Stdy-	So.Oxid.Stdy-SE Net Int Ox Res	So.Oxid.Stdy-91-92 Atlanta Intens.	So.Oxid.Stdy-94-95 Nash/MTN
Agency	EPA,TVA,So. Comp.,EPRI	EPA,TVA,Ga.Tech,BNL,NCSU,et	EPA,NOAA,TVA,BNL,20 U,35 Org	EPA,NOAA,TVA,BNL,20 U,35
Year Initiated	1992	1991-92	1991-1992	1994-95
Measures	Ozone,NOx,VOC,Met	Ozone,Spec.NOx, Spec.VOC,Met	Ozone Accum. In Atlanta	Ozone Accum. In Mid TN
Collection Source				
Point				
Source				
Transect				
Other area				
Locations for Data Collection	3-11 sites in 5 states	4 sites in 4 states	88 sites in 6 states	111 sites in 11 States
Temporal Interval	1 minute	5 minute		
Sampling Design				
Random				
Selected	Rural Sites	Rural Sites	Urban & Rural Sites	Urban & Rural Sites
Synoptic				
Data Available	Data Archive	Data Archives	Data Archives	Data Archives
Accessible	Yes	Yes	Yes	Yes, in future
Extent for Reporting	Intersite Comp.	Ozone Accum. Res.	Rural Urban Exchange	Rural Urban Exchange
Partners				
International				
Agency	EPA Region IV	NOAA, TVA, BNL	NOAA, TVA, BNL, EPA Reg IV	TVA,NOAA,BNL,EPA Reg.IV
State	5 States, EPRI		6 Soeast States	11 Soeast. States
Local				
Authorities/Reason for Prog	Ozone Precursor Relat.	Ozone Precursor Relat.	Reg. Ozone Res.	Reg. Oxid. Res
Users of Data per Year	50 per year	50 per year	200 per year	200-300 per year
Program Meets Metadata Stand.	Yes	Yes	Yes	Yes
Expansion of Prog(Needed/Not)	Yes	No	No	No
Contact Person	Eric Edgerton	F.Fehsenfeld, J.Meagher	M.Rodgers, J.Meagher	J.Meagher,F.Fehsenfeld
Phone #	919-544-3903	303-497-5819, 205-386-2342	401-894-5809, 205-386-2342	205-386-2342, 303-497-5819

MAJOR REGIONAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS

Mid-Atlantic Region Monitoring Programs - Part 8

Program Name (Acronym)	Ambient Toxicity	CPS	ATMET	
Program Name (Full)	Ambient Toxicity Testing	Coastal Plain Streams	Atrazne / Metal Achlor	Effluent Biomonitoring
Agency	EPA	DNR	MDE/CIBA GEIGY	Wye Research & Education Center
Year Initiated	1990	1992	1995	1987
Measures	Biological Endpoints, Contam.	Fish,Phys.Hab.,Water Qu	Atrazine/Metal Achlor	Toxicity
Collection Source				
Point				NPDES permitted discharges
Source				
Transect				
Other area				
Locations for Data Collection	Tidal Areas, Ch.Bay W/shed	Coastal Plain Streams	Mainstream Bay, Estuaries, Str.	Wye Bioassay Laboratory
Temporal Interval	Spring,Summer,Fall	Spring,Summer,Fall	March-Aug,& November	Yearly for Each Site
Sampling Design				
Random				
Selected	Selected	Selected	Selected	Yes
Synoptic				
Data Available	Reports	Reports	Reports	Yes
Accessible	Yes	Yes	Yes	Electronic & Hard copy
Extent for Reporting	Annual	Annual	Annual	Weekly
Partners				
International				
Agency				
State	DNB MDE			Maryland Dept of Environment
Local				
Authorities/Reason for Prog	Assess Ambient Toxicity	Develop Bio. Indicators	Ecological Risk	
Users of Data per Year	?	?	?	State Govt, Indstry, Municip.
Program Meets Metadata Stand.	?	?	?	Yes
Expansion of Prog(Needed/Not)	Needed	Needed	No	Not Needed
Contact Person	Lenwood Hall	Lenwood Hall	Lenwood Hall	Daniel J. Fisher
Phone #	410-827-8056	410-827-8056	410-827-8056	410-827-8456

MAJOR REGIONAL ENVIRONMENTAL MONITORING & RESEARCH NETWORKS & PROGRAMS				
Mid-Atlantic Region Monitoring Programs - Part 9				
Program Name (Acronym)				
Program Name (Full)	Wye Watersheds			
Agency	MAES			
Year Initiated	1984			
Measures	Anions, pH Ground Water Elev.			
Collection Source	Runoff, Leaching &Groundwater			
Point				
Source	Continuous for Surface Water			
Transect	Transect for Groundwater			
Other area				
Locations for Data Collection	Wye Research & Educ. Center			
Temporal Interval	Continuous			
Sampling Design	Paired Watersheds			
Random				
Selected				
Synoptic				
Data Available	Hard Disk			
Accessible				
Extent for Reporting	Reports, Publications			
Partners				
International				
Agency	MAES			
State	DNR/MDA			
Local				
Authorities/Reason for Prog				
Users of Data per Year	Scientists,Policy			
Program Meets Metadata Stand.				
Expansion of Prog(Needed/Not)				
Contact Person	Kenneth Staver			
Phone #	410-827-8056			